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EAST AFRICA HIGH COMMISSION

EAST AFRICAN AGRICULTURE
AND
FORESTRY RESEARCH ORGANISATION

ANNUAL REPORT
1956

RECORD OF RESEARCH

For the Period 1st July, 1955 to 30th June, 1956

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CONTENTS

Page

THE STAFF OF THE EAST AFRICAN AGRICULTURE AND FORESTRY RESEARCH ORGANISATION

PREFACE 1

INTRODUCTION

The Progress of Research 3

THE APPLICATION OF PHYSICS TO AGRICULTURE AND FORESTRY

Catchment Area Research 7
Soil Structure Studies 9
Irrigation Studies 10
Agricultural Meteorology 11
Liaison Work 15

RAINFALL AND CROP YIELD

The Reliability of Seasonal Rainfall 16
Rainfall and the Yield of Wheat in the Kenya Highlands . 16
Drought and Maize Yield 17

ADVANCES IN SOIL SCIENCE

Soil Fertility Studies 18
Organic Matter and Humus Decomposition 18
Studies of Sulphur Metabolism in Soils and Muds . . . 22
Soil Microbiology 25
Analytical Services—Chemical 28
Analytical Services—Spectrochemical 29
Soil Survey 35

PLANT IMPROVEMENT AND PROTECTION

Cassava Breeding 44
Groundnuts 45
Application of the Brieger Method to Maize Breeding . . 45
Incorporation of Streak Resistance into Maize . . . 46
The American Rust Disease of Maize 47
Virus Diseases of Sweet Potato 51

FORESTRY

Silvicultural Research 54
Information Services 54
Standardisation of Research Procedure 55

Research on Softwoods 55
Enumerations 67
Regeneration of Hardwoods 67
Short-term Tree Cropping 67
Yield Tables for Important Species 68
Muguga (E.A.A.F.R.O.) Estate 68
Forest Entomology 68

HORTICULTURE 71

SYSTEMATIC BOTANY
The Work of the East African Herbarium 73
Field Work 77

THE DEVELOPMENT OF ANIMAL INDUSTRY RESEARCH
Survey of Progress 79
Minimum Size of Experimental Plots for Assessment of Pasture Yield 82
Apparent Digestibility of Crude Protein by the Ruminant . 83
Attempted Chemical Method for Determining the Digestibility of Crude Protein 84
Carbohydrate Studies on Herbage 85
Principal Results of Digestibility Trials using Sheep . . 87
Preliminary Genetical and Behaviour Studies on the Muguga Zebu Herd 92
Experiments on the Feeding of Bacon Pigs 94
Egg Yields from Locally-bred Poultry 98
Experimental Farm 100
Miscellaneous Investigations 102

MISCELLANEOUS SCIENTIFIC SERVICES
Joint E.A.A.F.R.O./E.A.V.R.O. Library 104
East African Agricultural Journal 105
East African Plant Quarantine Station 106

ATTACHED C.D. AND W. SCHEMES
Ecological Training Scheme 110
East African Cereal Pests Survey 112

LIST OF PUBLICATIONS BY E.A.A.F.R.O. STAFF DURING THE PERIOD 1ST JULY, 1955, TO 30TH JUNE, 1956 114

THE STAFF OF THE EAST AFRICAN AGRICULTURE AND FORESTRY RESEARCH ORGANISATION AT THE 30th JUNE, 1956

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PREFACE

The East African Agriculture and Forestry Research Organisation (E.A.A.F.R.O.) is an inter-territorial research organisation administered by and forming part of the East Africa High Commission. It was set up in 1948 and absorbed the earlier East African Agricultural Research Institute, at Amani, Tanganyika, which was started in 1927. E.A.A.F.R.O. is financed jointly by the three East African Territories of Kenya, Tanganyika and Uganda, by the Protectorate of Zanzibar, and by the United Kingdom Government through Colonial Development and Welfare funds. Its Headquarters and central laboratories, experimental farm and forest plantations are in Muguga Forest, near Nairobi, on a site generously given by the Government of Kenya.

E.A.A.F.R.O. works very closely with the corresponding organisation for veterinary research, the East African Veterinary Research Organisation (E.A.V.R.O.). The two Organisations have a common Headquarters at Muguga and the two sets of laboratories and farms are on neighbouring estates each excised from the Muguga Forest. They are jointly responsible for the Library, which is the largest and most complete library for agriculture and the agricultural and ancillary sciences in East Africa. In addition they are also jointly responsible for work on animal industry, or animal husbandry, which is carried out in the Joint Animal Industry Division under a Deputy Director. The Deputy Director however has retired at the end of the year under review, and it is likely that there will be changes in the way this joint work is administered though not with the general principle that it is a joint responsibility of the two Organisations.

The general policy both for E.A.A.F.R.O. and for E.A.V.R.O. is decided by the East African Agricultural and Fisheries Research Council—a Council whose members are nominated by the Territorial Governments, the High Commission and the Colonial Office, and this Council is also responsible for the general running of both the Organisations.

The principal functions of E.A.A.F.R.O. are to undertake research work that is either longer term than is easily undertaken by the Territorial Departments of Agriculture and Forestry, or is common to all or several of the Territories, or which requires highly specialised equipment or research officers which can only be justified in a central East African laboratory. Examples of each of these types of work will be found in the body of this Report. E.A.A.F.R.O. however is only concerned with problems of local interest when specially invited by a Territorial Department. Its function is therefore to supplement and supply the background to the work of the Territorial research workers.

The planning of the detailed research policy of E.A.A.F.R.O. must obviously be done in very close co-operation with the Territorial Departments and this is ensured through the Agriculture, Animal Industry and Forestry Research Co-ordinating Committees, set up by the Research Council under a High Commission Chairman, which are composed of the Territorial Directors of Agriculture and of Veterinary Services and the Chief Conservators, the Director E.A.A.F.R.O., and for the Animal Industry Committee the Director E.A.V.R.O. These Committees, in conjunction with the Research Council, keep under review all the research work in progress, and decide on general priorities for research, particularly of the longer term or more specialised research that is the direct concern of E.A.A.F.R.O.

E.A.A.F.R.O. is also directly concerned with a further set of Committees, the Specialist Committees, which are composed of the actual specialist research workers in East Africa in each of the disciplines represented. These Committees are therefore competent to discuss the technical problems the research workers are faced with in carrying out their work, and to make detailed proposals for new work or for the extension of current work.

It was decided at the 3rd Meeting of the Research Council, held on the 3rd February, 1955, that in future the Annual Reports of E.A.A.F.R.O. should be published in two parts. One part, which is contained in the Annual Report of the Research Council itself, is intended to tell the non-scientist of the work and achievements of E.A.A.F.R.O. in the year under review. The other part, which is this Report, is written more for the information of research workers, particularly in other parts of the world.

INTRODUCTION

1. *Staff Changes.* The new Director arrived in November, 1955 and was able to release Dr. H. H. Storey from his administrative duties as Acting Director. It is very satisfactory to report that it has been possible to re-engage Dr. Storey subsequent to his official retirement as pathologist-in-charge, so allowing him to devote his whole time to his work in plant pathology.

2. Two new research officers joined the staff at Muguga during the year: Dr. J. S. G. McCulloch who joined the Physics Division and Dr. J. W. Millbank, our Microbiologist who was in training at Rothamsted Experimental Station. Two research officers have left: Dr. M. H. French retired from the Deputy Directorship and Head of the Joint Animal Industry Division at the end of the year, and Mr. B. E. St. L. Stuart resigned to take up an appointment with the Kenya Forestry Department. Miss D. M. Napper joined the staff of the E.A. Herbarium as a Scientific Assistant and P. Howland joined the Muguga staff as a Forester.

3. Of the Attached Schemes financed entirely out of C.D. & W. funds, the Termite Research Unit has now been wound up in East Africa, and so has the Ecological Training Scheme, but Mr. C. G. Trapnell who was Ecologist-in-charge of the Scheme now holds this position on the E.A.A.F.R.O. staff. A new scheme on a Survey of Insect Pests of Cereal Crops has been started and Dr. I. W. B. Nye, the Entomologist-in-charge, arrived and has begun work. At the E.A. Plant Quarantine Station, which is situated at Muguga, Mr. P. J. Dickinson has replaced Mrs. G. A. Quinion as Horticulturist.

THE PROGRESS OF RESEARCH

4. I only propose to mention in this Introduction a few of the principal developments that have taken place at E.A.A.F.R.O. in the year under review. I also want to take this opportunity of emphasising that since E.A.A.F.R.O. is an inter-territorial station a very great deal of the work described here could only have been done with the very ready and active co-operation of many research and administrative officers in the Territories. It is a great pleasure to acknowledge here the great help they have given us and to thank them all for it.

5. It is very fitting that the first development to be described should be an excellent example of the value of an inter-territorial research station in being able to help organise experimental work involving many

Departments in each of the three Territories. A series of three closely related experiments, one in Tanganyika and two in Kenya, on the effects of changes of land use in high catchment areas on the evenness of river flows have been started, and it is hoped shortly that a fourth, concerned with the effects of continuous as opposed to rotational grazing, will be started in Uganda. This series of experiments is being co-ordinated through the Physics Division and they will also be responsible for the soil sampling and the computations required, whereas the Territories are being responsible for the measurements of rainfall, river gauging and the local administration.

6. This work links up closely with other measurements this Division is making on the amount of water transpired by different types of vegetation cover and with research into the factors which control this amount. This should lead to finding more accurate methods for computing the water loss from meteorological or other readily measurable data. It also links up with the work of the plant physiologist on the reliability of the long rains in those parts of East Africa where it has agricultural significance, and on the effects of excess rainfall or of drought on the performance of crops in East Africa.

7. The principal development in the Chemistry Division has been what appears to be a very promising study of the factors which control the rate of decomposition of humus in East African soils; and as one would expect, the results being found are likely to have fairly general application on many tropical and sub-tropical soils outside East Africa. The other study that is progressing in this Division is on the sulphur cycle in East African soils. Shortage of sulphates limits crop growth very seriously in several parts of the world, and whilst it is fairly certain this occurs in parts of East Africa, it is probably not widespread. But on our present knowledge it is far from clear why it is not common and what are the mechanisms responsible for maintaining an adequate sulphate supply to the crop on the old well-drained and deeply weathered land surfaces.

8. The Organisation, and earlier the East African Agricultural Research Institute have been engaged in breeding cassavas as resistant as possible to the virus diseases, mosaic and brown streak, of cassava. In 1937 Dr. Storey at Amani, in co-operation first with Mr. R. F. W. Nichols and after his death in 1951 with Mr. L. R. Doughty, began a collection of cassavas from other parts of the world which were resistant to mosaic, for none have been found immune. First crosses of some of

these were found to be so satisfactory that they have been multiplied up and are still used in Uganda, where the intensity of mosaic infection is only moderate. Their resistance however was too low to be of importance in coastal areas, where the intensity of infection is very high. At the same time, an attempt was made to obtain a much higher degree of resistance, and if possible immunity, by producing crosses with other species of *Manihot* believed to be immune, and back-crossing these hybrids with resistant and otherwise desirable cassavas. This breeding work is now being brought to a close. Seedlings of improved resistance have been obtained, but no seedlings have shown immunity, and the best of these are now being tested in various parts of the Territories. The future policy will be to maintain at Amani a nursery of seedlings having as high a resistance to these viruses as possible, as well as clean plants belonging to any clones that are distributed to the Territories. Hence if a good clone goes down in the course of years to these viruses in areas where infection is high, clean material will always be available, for insects transmitting these diseases are not present at Amani.

9. One very important practical result that has come out of the silvicultural work is a much better understanding of the principles underlying good nursery and transplant bed techniques for the production of strong and vigorous plants of exotic softwoods. As a consequence, although in general E.A.A.F.R.O. does not normally do extension work, a number of courses for forest officers on nursery and plantation establishment problems have been held at Muguga, and the Horticulturist is being invited by the Territories to tour some of their forest nurseries and demonstrate the new techniques on the spot.

10. Two lines of work carried out by the Animal Industry Division are particularly relevant to the more agricultural side. One of these concerns the uniformity of grass growth over pastures that seem to be reasonably uniform. It has been found that during the rainy season, the uniformity is comparable with that found in temperate pastures, but during the dry season it is extremely uneven. This has the consequence that it is far more difficult than anticipated to measure productivity of pastures accurately during the dry season, and that many of the earlier results are much less reliable than had been assumed.

11. The second line of work which has developed rapidly concerns the digestibility of the crude protein, or total nitrogen compounds, in rations. In this context digestibility is defined as the proportion of the total nitrogen in the food that is not found in the faeces. A statistical

examination of all the digestibility trials with ruminants that had been made in East Africa was being undertaken, and this was later extended to all the world data available here. The result of this examination was that the digestibility of the nitrogen is principally controlled by the nitrogen content of the ration. It is the same with cattle, sheep and goats and for European as well as native African or Asian animals, and it depends very little on the kind of nitrogenous food in the ration. This result is sufficiently surprising and unexpected to justify much further work to elucidate some of its consequences.

THE APPLICATION OF PHYSICS TO AGRICULTURE AND FORESTRY

H. C. Pereira, J. S. G. McCulloch, P. H. Hosegood and E. Kasavuli

CATCHMENT AREA RESEARCH

12. The major objective throughout the year has been the organisation of a co-operative scheme of research into catchment area management, involving four major Government Departments in each of the three territories. In the rapid development of East Africa, water resources are everywhere a vital factor, and in many cases they are the factor limiting further progress. Serious, and often irreversible decisions on land use and management in the high-rainfall catchment areas must at present be made by administrations on the basis of opinion only, since the assembly of factual information on the effect of land-use changes on water resources has scarcely begun. The stream-flows from major catchments provide for large populations over the vast semi-arid areas in all three territories, and the effects of mistakes in land use at the headwaters can be far-reaching. Some of the serious mistakes that have, in fact, been made, were clearly described by the distinguished American hydrologist, Dr. Charles Hursh, in the E.A.A.F.R.O. Annual Report of 1952.

13. Factual information on the effects of major land use changes on water resources requires the co-ordinated measurement of meteorological, hydrological, forestry and agricultural factors, together with the help of administrations and the consultation of specialists such as geologists, surveyors, etc. Such co-ordination has not materialised in the past, since it requires a central nucleus of investigating specialists with this research as their main task. Following on Dr. Hursh's report, the Royal Commission on East Africa recommended that E.A.A.F.R.O. should provide this nucleus, and this was endorsed by the Research Co-ordinating Committees in Agriculture and in Forestry. This task has, therefore, been accepted as the major commitment of the Physics Division of E.A.A.F.R.O.

14. Dr. McCulloch arrived in September 1955, and has taken over the work in agricultural meteorology, as reported below. Further additions to the staff of the Physics Division, both by recruitment and by internal transfer, will enable the new commitments in catchment area research to be undertaken without dropping the lines already in progress.

15. Brief reconnaissances on the water relations of catchment areas were made during the year, at the request of territorial departments, in the following areas:—The North and West Kilimanjaro forest belt, the Mbeya Range, and the Elton Plateau in Tanganyika; the South-West Mau and the Southern Aberdare forests in Kenya; the Karamoja district in Uganda.

16. After informal discussions with the departments concerned, a Planning Conference on Catchment Area Research was held at Muguga in June. Some 36 specialists joined the discussions, and four major co-operative research projects were planned. These were:—

(1) The effect of large-scale replacement of bamboo forest by softwood plantations (Kikuyu Resettlement Scheme in the Aberdares).

(2) Effects of African peasant cultivation in high steep catchment areas; effects of closing land to cultivation, and effects of maintaining a tall forest cover in the newly created Mbeya Range Forest Reserve.

(3) Effects of replacement of tall forest by tea plantations in the Kericho area.

(4) Effects of grazing control on rainfall acceptance and flood flow in semi-arid catchments in the Karamoja district.

17. Subsequent detailed reconnaissance by joint teams of territorial and E.A.A.F.R.O. staff have confirmed the suitability of sets of valleys selected for all four studies. Encouraging progress has been made in the setting up of three of the experiments. The tea study has inevitably been somewhat delayed by the legal processes of land excision which must precede commercial tea development, but preliminary track-cutting and stream-gauging have begun, and engineer designs for the weirs are in preparation by the Kenya P.W.D.

18. The classical studies in the U.S.A. have involved measurements of streamflow over ten or more years before changing the land use, followed by a further ten years for the study of the effects of the change. The rate of progress can be greatly accelerated, however, if the reaction of each catchment to the various sizes of storm can be determined. This involves a continuous estimate of the soil moisture storage conditions, which determine whether rain can be absorbed. Studies outlined in previous Annual Reports have reached the stage at which this estimate

can be undertaken on a large scale. A power-driven core-drill capable of taking undisturbed soil cores to a depth of ten feet has been ordered from the Utah Scientific Foundation for this work.

19. Field studies in the water use of vegetation reported in previous years, were continued. The "dry farming" study of water conservation by fallows at Kongwa in Tanganyika was concluded during the year, and the results are being prepared for publication. Co-operation with the Kongwa Experiment Station of the Tanganyika Agricultural Corporation in evapotranspiration studies of local pasture grasses are continuing, both in the field and in irrigated tanks.

20. The comparison of soil moisture regimes under cypress plantations and indigenous bamboo reached the stage of the felling of the mature cypress, so that next year's contrasts will lie between vegetable crops grown in the cleared area, a four years' stand of Patula pine, and the adjacent undisturbed bamboo forest.

21. The study of the catchment basin under well-managed Kikuyu grass pasture has reached the eighth year of water use measurements and will be concluded in 1956.

22. The experiment at Muguga on the water balance of three grass-arable rotations, both on terraces and on 12% slopes, has begun to show sharp contrasts in behaviour. A poor distribution of rain in the first half of 1956 has resulted in soil profiles dry from the sixth foot downwards, under both *Cynodon dactylon* and *Pennisetum clandestinum* paddocks, with poor prospects for dry season grazing. By the co-operation of the Animal Industry Division, grazing yields on this experiment are now available in terms of live-weight gains of zebu beef cattle.

SOIL STRUCTURE STUDIES

23. The above rotation experiment at Muguga, now in its third year, already provides a range of soil conditions from complete stability to active erosion, and provides an excellent basis for development of rapid field tests for the structural condition of these red lateritic soils. Such a test will be of immediate use to soil conservation officers and other agricultural staff in the field. A description of a new laboratory test by which undisturbed soil cores are subjected to an artificial rain storm while held under a standard drainage tension was published during the year.

24. Co-operation with the Kenya Department of Agriculture in the Makavete grass establishment trials continued. The Department ploughed out and cropped 40 of 80 half-acre paddocks after five years under four different grass species and natural veld. Statistical analysis of the yields of the first test crop of beans after breaking up gave highly significant differences in initial fertility. Where no fertilizers had been applied to the paddocks, the natural veld grasses gave the highest bean yields, and the *Panicum coloratum* (var. *Makerikeri*) gave the lowest. Where the paddocks had received fertilizers annually for the past three years, Star grass gave the highest yields, and again Makerikeri grass the lowest. Star grass showed the highest residual response to fertilizers (over a 100% increase) while the other grasses showed between 30% and 40% increases. The subsequent crops of maize and sorghum unfortunately failed from drought. A progress report on this experiment was distributed in mid 1955 through the Chief Research Officer of the Department of Agriculture.

IRRIGATION STUDIES

25. A reconnaissance of the trial plots under development by the Tanganyika Agricultural Corporation (Rufiji Basin Survey) and core-sampling of five typical profiles, showed that very considerable irrigation difficulties could be expected in the widely varying mixtures of coarse sand, silt and clay in the flood plain of the Rufiji River. Similar core-sampling in the trial plots on the Bohoro flats showed highly favourable irrigation prospects. A brief reconnaissance of the catchment areas in the Elton Plateau, which now supply abundant water for potential irrigation development on these fertile flats, emphasised the need for long-term planning in the control of cattle populations in the province. Over-grazing on the peculiarly vulnerable volcanic tuff of the plateau could very rapidly destroy what is probably the most promising of irrigation resources in East Africa.

26. At the invitation of the Hydraulic Engineer of the Kenya P.W.D., joint work has been undertaken with the Hydrology Section on the problems of water distribution on newly-cleared land in the Perkerra Irrigation Scheme near Lake Baringo. The use of the single heavy flooding to irrigate the maximum area from the peak floods of the highly seasonal Perkerra River has been shown to be impractical in the heavy silty soils commanded by the Scheme. Crop roots are confined by lack of air to the first two feet of flooded soil, and crops subsequently fail,

while available soil moisture lies unused below two feet. Study of numerous soil profile samplings showed that neither ridge and furrow, nor the flat basin system of watering were able to secure even penetration of water over areas from which tall acacia had been newly cleared.

27. At the request of the Agricultural Department a joint experiment with them to establish the most economic rates of watering the crops on the scheme has been undertaken. The area commanded exceeds the irrigation potential of the dry-weather flow of the Perkerra River, and water economy will be essential. Electrical resistance and tensiometer information, supplemented by deep-soil sampling, is now being compared with evaporation estimates, both from pans and from the Penman analysis of weather data, while water applications are measured.

AGRICULTURAL METEOROLOGY

28. Routine observations of rainfall, air temperature and humidity, sunshine hours, and run of the wind at one and two metres height, were continued at the meteorological enclosure at Muguga, using the standard equipment installed in 1953, and a summary of the data for the full year 1955 is presented. Evaporation figures obtained from the sunken pan, Australian pattern deep tank and the raised pan are also quoted. The year 1955 was slightly drier than average for the stations round Muguga; (sufficient data have not yet been obtained at Muguga to justify quoting average values). The long rains were rather poor, and the short rains failed to materialise until the extreme end of the year. The annual mean air temperature showed a variation of only 0.2° F from that obtained in 1954, although there was a slight increase in the hours of bright sunshine (5%) and in the mean wind speed (10%). These resulted in a 10% increase in open water evaporation from the shallow four feet diameter tanks. The result obtained with the Australian three-feet deep sunken tank, which is the tank recommended as standard by the World Meteorological Organisation, is some 5% less than that recorded by the simpler Muguga sunken insulated pan, and some 15% less than the evaporation from the raised gridded pan, which is the standard Kenya Public Works Department equipment.

29. The use of the Gunn Radiation Integrator has been discontinued since the prototype has been dispatched as a sample to Messrs. Baird and Tatlock (London) Ltd., the firm of scientific instrument makers who have undertaken the commercial production of the instrument. It is understood that the first batch of these instruments is now available.

SUMMARY OF METEOROLOGICAL OBSERVATIONS AT MUGUGA, 1955

	RAINFALL	AIR TEMPERATURE			AIR HUMIDITY			WIND-SPEED	SUNSHINE	OPEN WATER EVAPORATION		
		MONTHLY MEANS OF DAILY VALUES								MONTHLY TOTALS		
	Monthly Totals	Maximum	Minimum	Mean	Dew Point mean of 8030-1600	Saturation Deficit Mean of 0830 and 1600 hrs.	R.H. at 1600 hrs.	Mean Wind Speed at 6 ft. above ground	Mean Daily Sunshine Hours	Sunken Pan Insulated From Soil	Australian Pattern 3 ft. Deep Sunken Tank	Raised Pan with Heavy Grid Cover
	Inches	° F.	° F.	° F.	° F.	mm. of Mercury	%	M.P.H.	Hours	Inches	Inches	Inches
Jan.	1 06	73 9	52 5	63 2	51 0	5.2	45	8 7	9 9	7.46	6 97	8.76
Feb.	2.33	72 8	52.7	62.8	52 0	4.7	53	6 7	7.7	5.43	5 24	6.27
Mar.	1 40	74.9	53.9	64.4	52 0	5.4	41	10.0	9.5	8.56	7.89	10.18
Apr.	7 47	70 3	56 4	63.4	54.0	4.2	58	8.2	8.0	5.72	5.38	6.08
May	4 03	66 9	52.8	59 8	54.0	2.4	66	5.7	6.7	4.04	3.82	4.43
June	0 13	66 1	49 0	57 6	51.5	2.4	60	5.0	6.3	4.02	3.90	4.37
July	0 88	65 7	48 2	57 0	50.5	2.5	62	4.6	4 6	3.67	3.40	3.99
Aug.	1 88	68 1	48 3	58 2	51.5	2.7	62	4.6	5.6	4.15	3.95	4 65
Sept.	1 96	69 5	49 2	59 3	51 0	3.3	55	5.3	5.8	4.43	4.32	4.84
Oct.	2.09	71 4	52 8	62 1	51 0	4 6	47	8.2	7.7	6.50	6 26	7 34
Nov.	1 18	70 7	53 0	61 9	53 0	3 8	56	8.8	8.2	6 10	5 73	6.78
Dec.	5.54	71 5	52 7	62 1	52 5	4.1	54	8.8	8.3	6.75	6.51	7.42
Annual Totals	29 95	—	—	—	—	—	—	—	2,684.6	66.83	63.37	75.11
Annual Means	—	70 2	51.8	61.0	52.0	3.8	55	7.0	7.4	—	—	—

30. Penman's formula for potential evaporation from an open water surface has been applied, with encouraging results, to weather data obtained at different altitudes in Kenya. The difficulties involved in checking the formula are considerable since, as Penman comments, the only method of measuring true evaporation is more approximate than the formula. However, it is hoped that with the deep loam soils of East Africa it will be possible to obtain an adequate water balance over selected catchment areas. In the meantime, correlations of the Penman estimates with measured open water (pan) evaporation have given a consistent relationship with a very modest scatter. An extension of this work of comparing actual pan evaporation with the theoretical computation has been begun, and data for this purpose are being assembled from all three territories.

31. *Soil Temperature Studies.* A considerable wealth of data on soil temperatures is available for temperate latitudes, but very little for equatorial latitudes. Therefore, in 1953 six mercury-in-steel thermographs were checked by comparison, and installed under bare soil in the meteorological enclosure at Muguga, at depths of 1, 3 and 6 inches and 1, 2 and 3 feet. After two years of continuous records (broken only by clock failure of one instrument) had been obtained, an analysis was begun of the annual flow of heat in the soil, and especially of the diurnal flow of heat under different seasonal conditions. To illustrate the annual variation of soil temperature at Muguga, and to show its remarkable uniformity throughout the year, a table is appended showing the mean daily maximum and minimum temperatures for each month in 1955, at each depth to 6 inches. At and beyond 1 foot depth, the diurnal variation of soil temperature is less than the limit of accuracy of the instruments in use ($\frac{1}{2}$° F), and mean monthly values only are quoted. It is of interest that, at 1 inch depth, the mean monthly minimum temperature varies throughout the year by only 4° F, and that even the mean maximum temperature range is relatively small, from 88-106° F.

32. It should be noted that mean monthly temperature values obtained by averaging the maximum and minimum at 1 and 3 inches give values which are approximately 5° F and 1.5° F respectively higher than the true mean value obtained by numerical integration over the period. This is contrary to the general opinion in the literature on the subject, and it is hoped to publish this data in the near future.

33. The thermal diffusivity of the soil at three depths, at different times of the year, has been calculated from the average diurnal variation

MONTHLY MEANS OF SOIL TEMPERATURE ° F. UNDER BARE SOIL, MUGUGA, 1955

Depth	Jan. Min.-Max	Feb. Min.-Max.	Mar. Min.-Max.	Apr. Min.-Max.	May Min.-Max.	June Min.-Max.	July Min.-Max.	Aug. Min.-Max.	Sept. Min.-Max.	Oct. Min.-Max.	Nov. Min.-Max.	Dec. Min.-Max.
1″	58-105	56-97	58-106	58-90	57-88	56-95	54-93	55-88	55-94	59-95	56-94	57-94
3″	64-85	62-82	65- 86	62-80	61-78	61-79	59-75	59-78	60-80	62-82	61-81	61-81
6″	67-72	66-71	68- 73	66-70	65-69	65-69	62-66	63-67	63-68	65-71	65-70	65-70
1′	69	68	69	67	66	67	64	64	65	66	67	66
2′	66	66	67	66	66	66	64	64	64	65	65	65
3′	68	68	69	68	67	67	66	65	66	66	67	67

of temperature over a number of selected ten-day periods. The diffusivity was found to fall sharply with depth, as can be seen from the following results, but to be little affected by moisture content, with the consequence that the diffusivity is almost constant throughout the year below a depth of 3 inches.

Depth Range Inches	*Mean Diffusivity c.g.s. Units*	*Temperature Wave Velocity*
1 — 3	0.0033	1″ per hour
3 — 6	0.0016	$\frac{2}{3}$″ per hour
6 — 12	0.0008	$\frac{1}{2}$″ per hour

34. The rate at which the temperature wave penetrates into the soil may be of general interest. The temperature maximum at 6 inches is reached at about 8.00 p.m., and at 12 inches at about 8.00 a.m.

LIAISON WORK

35. Dr. Pereira, as Secretary of the Eastern Regional Committee for the Conservation and Utilisation of Soil, set up by the Commission for Technical Co-operation in Africa South of the Sahara (C.C.T.A.), assisted the Tanganyika Department of Agriculture in the preparations for the "Conference on Soil Conservation", which was held at Dodoma at the end of June. A talk on climatic factors in tea plantations was given to the Kenya Tea Planters' Association at Kericho, and an address on catchment area research was given to the Water Resources Conference, held in Nairobi by the Kenya Water Authorities. Two meetings of the Sisal Research Committee were attended at Tanga, and two meetings of the Tea Research Institute at Kericho.

RAINFALL AND CROP YIELD

J. Glover

THE RELIABILITY OF SEASONAL RAINFALL

36. Following on the production of maps of the reliability of annual rainfall for East Africa, work has been started on producing maps of the reliability of season rainfall, the two rainfall values chosen being 15 inches and 20 inches. Most of the Kenya and Uganda records have been extracted and analysed, and this data will shortly be plotted on maps. An interesting problem in the mapping of seasonal rainfall from the agricultural standpoint has arisen. In most of Kenya and Tanganyika the rainy seasons are clearly separated from each other by well marked intervening dry seasons which are unfavourable to annual crops. The rainy season, as recognised by the meteorologist, is therefore also the crop season of the agriculturist, and as a result the reliability of seasonal rainfall at a given place gives a good estimate of the reliability of the production of annual crops there. This simple relationship does not however hold in some parts of Uganda. In these regions the intervals between the rainy seasons, as recognised by the meteorologist, are often merely periods of reduced but nevertheless reasonably reliable rainfall, and a crop planted in one rainy season may be tided over into the next by such rains. If one adheres to the "official" rainy season for mapping purposes, a poor guide to the crop season may be presented. It is possible to provide a solution of this difficulty by presenting tables of the reliability of rainfall during certain potential crop seasons, but as there may be several of these in the year they cannot be mapped in simple form.

RAINFALL AND THE YIELD OF WHEAT IN THE KENYA HIGHLANDS

37. The relationship between the yield of wheat and seasonal rainfall in the Kenya Highlands has been studied in the same way as that for maize (see Annual Report 1955). Unlike maize, wheat appears to be very sensitive to slightly excessive rain, particularly at planting time and at maturity. If the crop receives more than slight amounts of rain at these periods yield is depressed. As in Europe and elsewhere it seems to do best under well distributed light rains, which cease about the time the heads are filled.

38. The rainy season, particularly in the west Rift area, seldom provides these conditions. It is longer than the growing season, so it

is difficult to select planting dates which will enable the crop to avoid most of the heavy rain. If the crop is planted at the time of the slight intermittent rains early in the wet season it will, in general, mature in a period of heavy rains when it is easily attacked by rust; on the other hand, if planting is delayed until the rains are well established, the heavy rain at planting will depress yield, and drought when the rains cease may further depress it. At the moment there seems to be no simple means of escape from this dilemma.

DROUGHT AND MAIZE YIELD

39. Studies of physiological changes associated with drought have been started. The wilt associated with partial drought in maize appears to have an effect on yield which is disproportionate to its apparent severity. In many parts of East Africa it is not uncommon to find the maize crop partially wilted, and often this wilt persists for a week or more. Full leaf turgidity is restored with the onset of rain, and the crop does not seem to have suffered severely. However, preliminary trials of growth, when water is deliberately withheld from crop, show that even a week of partial wilt can produce a marked set back from which the plant does not easily recover and, although adequate water supplies are restored, maturity is delayed and yield may be depressed.

40. In these studies stomatal movement and cell turgor are being examined. The stomata of maize open readily under dull insolation and remain open all day until evening, unless heavy cloud causes them to close. With the onset of wilt, however, they close even in bright sunshine, thereby reducing water loss. When the water supply is restored the leaves quickly regain their turgidity, but the stomata do not fully reopen, even under adequate insolation, until some hours later. The pattern is not yet established, for on some occasions the stomata do not behave normally until some 24 hours have elapsed from the time full turgidity has apparently been restored in the leaf cells. It is possible that such delays may reduce photosynthesis, and a crop exposed to frequent partial wilting may be a partially starved crop, resulting in delayed maturity and a reduced yield.

ADVANCES IN SOIL SCIENCE

SOIL FERTILITY STUDIES

H. F. Birch and M. T. Friend

41. These studies are approaching completion and the position, to date (April 1956) is as follows: Crop response data for 150 field trials (including 30 exploratory trials) dating from 1952, have so far been received. These trials were laid down by Officers of the Kenya and Tanganyika Departments of Agriculture. Soil samples relevant to 66% of the trials and plant samples relevant to about 12% have so far been sent to E.A.A.F.R.O. for analysis. The soil analyses are virtually complete (616 of the 736 received), while, of the 713 plant samples received, all have been analysed for nitrogen and phosphorus (the principle nutrients of interest in these fertility studies) and 258 for bases.

42. It is estimated that within two years' time not only will the analyses be complete but also an assessment will be reached of the value of soil and plant analysis in soil fertility studies in East Africa. This will indicate which of the current routine analytical determinations can be rejected and which should be modified. The need for new types of analysis may also be revealed. In nitrogen studies, for example, the lability of the humus fraction, under different seasonal conditions, may be important as shown in the following paragraphs of this report dealing with organic matter.

ORGANIC MATTER AND HUMUS DECOMPOSITION

43. In the Annual Report for 1955 it was stated that the organic matter and nitrogen contents of East African soils were found to compare favourably with those of temperate soils. The amounts were most closely related to rainfall (an important factor in vegetative growth and therefore organic matter supply) and clay content (which appears to exert a protective effect against decomposition of part of the humus derived from the organic matter). Since the humus fraction comprises by far the largest proportion of total soil organic matter in most agriculturally important soils, decomposition studies with particular reference to this fraction have recently been carried out. Some interesting results have been obtained which are discussed, briefly, below.

44. For the decomposition studies a respirometer was employed. This maintained the samples under uniform conditions of temperature,

moisture and oxygen supply and afforded a continuous record of oxygen uptake and a periodic record of carbon dioxide evolution i.e. of the magnitude and, roughly, the kind of decomposition taking place. A full description of the apparatus has been published.

45. With the soil samples so far tested in this apparatus the rate of organic decomposition decreased linearly with the logarithm of the time and conformed to a first order reaction i.e. the rate of decomposition was proportional at any particular time to the amount of decomposable material present. The decrease in rate was shown not to be due to fall in pH, the accumulation of toxic compounds or an adverse effect of environment limiting microbial activity. In short, the respirometer measured the amount of decomposable material present under the conditions obtaining in the respirometer.

46. When moist soils were taken from the respirometer, dried, re-wetted to the original moisture level and returned to the respirometer a marked flush of decomposition occurred. This flush was found each time the soil was dried and re-wetted and its magnitude and the respiratory quotient of the decomposition remained relatively constant for each successive drying and wetting. The more intense the drying the greater was the magnitude and duration of the decomposition but the material decomposed appeared to be similar. It was shown that the drying effect could not be explained on the grounds that drying had (a) stimulated microbial activity (b) destroyed toxic compounds, (c) liberated N.P. and K., or (d) killed off part of the microbial population making this available for subsequent decomposition. All the evidence available indicated that drying had liberated from the clay readily decomposable material which, under steady moist conditions, was protected by the clay from microbial attack.

47. The magnitude of the flush was found to depend on the kind and amount of clay and the amount of organic material associated with it. More exact determinations have yet to be made, but the following data indicate the possible magnitude of such a flush. A single air drying of a forest soil (5.4%C) liberated rapidly decomposable material equivalent to 0.011g.C. per 100 g. soil (or 220 lbs/acre 6″ if this weighs 2×10^6 lb.). Replacement of this material, if of a humic nature, would involve the decomposition of about 1,700 lb. of dry plant material on the basis that this contains 50%C, 75% of which is lost as carbon dioxide during decomposition to humus.

48. Subsequent experiments with sand-pure clay mixtures showed that clay could, to a certain extent, protect gelatine from microbial attack and that the protected material could be liberated in discreet amounts with successive dryings and re-wettings. In these respects clays of the expanding lattice type (montmorillonite) were more effective than those of the non-expanding type (kaolinite). Since gelatine is rapidly decomposable, this behaviour confirms the importance of the clay fraction in protecting organic material from microbial attack. This protective action has been reported in the literature but nobody hitherto appears to have demonstrated that significant amounts of protected material can be liberated merely by air-drying the soil or clay.

49. There is evidence that the material liberated by drying can also be liberated by exchange with other organic compounds. For example, when gelatine was added to two moist soils, slowly respiring, the respiratory quotient (R.Q.) for the active decomposition period following the addition was similar to that following oven-drying and re-wetting in earlier experiments with the same soils, namely 1.29, and considerably above the theoretical value (0.8) obtained with gelatine decomposition in sand-pure clay mixtures. This indicates that gelatine was protected from decomposition by displacing material similar to that liberated on drying.

50. Finally, when a sandy soil (10% clay) from Ukiriguru with a low humus content (0.15%C) was placed in the respirometer, the magnitude of decomposition and of the drying effect were very small. When, however, plant material (0.25g. per 50g. soil) was added, decomposition took place which was almost complete after 13 days when 53% had decomposed. Subsequent dryings and re-wettings then released quite significant amounts of decomposable material, presumably the decomposition products of the plant material which had interacted with the clay.

51. From the experimental data so far available the following conclusions may tentatively be drawn.

(a) Depending on the kind and amount of clay present a soil can retain considerable quantities of organic material resulting from the decomposition of macro-organic matter (plant residues etc.) This organic material is very decomposable but under moist conditions (conducive to microbial attack) it is afforded a considerable degree of protection by the clay. On drying,

some of the protected material is liberated, but is not attacked because microbial activity is low under dry conditions. On re-wetting, when microbial activity is again possible, the liberated material is rapidly decomposed.

(b) The clay fraction must, to a certain extent, be restricted with regard to the kind of organic compounds with which it can interact. This will lead to a certain degree of uniformity in this particular humus fraction. It appears, from the amounts of carbon and nitrogen mineralised to be of fairly low C/N ratio (about 15-20). Further, since humus decomposition and ammonia accumulation usually go together the period of rapid decomposition on re-wetting should coincide with a rapid mineralisation of nitrogen and other nutrients. This organic fraction, both in its nature and the critical period during which it is active (at start of the rains) must be an important factor in soil fertility.

(c) Where wet and dry seasons alternately prevail the pattern or cycle of soil organic matter (humus and litter) may be visualised as follows: at the start of the rains rapid decomposition of the material liberated during the previous dry season will take place. Concommitantly breakdown of any macro-organic material (leaf litter etc.) that may have accumulated will take place. Decomposition products from this will be able to replace those lost during the flush of decomposition. As the soil dries out after the rains the cycle will start again.

52. The experiments and conclusions outlined above offer a satisfactory explanation for the following observations.

(a) The beneficial effect of burning. Burning would cause an enhanced release of decomposable material over ordinary drying with liberation of nitrogen on re-wetting. In soils with a poor reserve of decomposable material burning will hasten exhaustion. Where the reserve is high and organic residues are periodically returned to the soil it may have something to commend it.

(b) The nitrate flush. This refers to the formation of large amounts of soil nitrate at the start of the rains. The drier the soil prior to the rains the greater, generally, is the magnitude of the flush.

The liberation of decomposable material during the dry season and its rapid decomposition and mineralisation at the onset of the rains could account for this.

(c) The so-called priming action of fresh organic matter additions to soils on the decomposition of the soil humus has been reported in the literature. This is generally ascribed to increased microbial activity following the application of energy material. It appears equally probable that the action is merely one of exchange between decomposition products from the added plant material and the material retained by the clay.

53. It is expected that the respirometer will find increasing application in work of the kind described and also in soil fertility studies involving humus and nitrogen, particularly with reference to the effect of rainfall. It is already clear that under prolonged moist conditions the rate of decomposition, and consequently of nitrate production, may sink to a very low rate.

STUDIES OF SULPHUR METABOLISM IN SOILS AND MUDS

P. R. Hesse

54. *The distribution of sulphur in forest soils.* Apart from the gradual oxidation of organic sulphur to sulphate in the topsoils of forests, an additional cycle has been found in which sulphate is leached directly from the vegetation. The fresh leaves of the forest trees contain appreciable quantities of sulphate (30-300 p.p.m. SO_4-S dry wt.) and analyses of rainwater have shown that the rain falling on the soil under forest cover contains more sulphate than does that falling on nearby open land. Using the respirometer technique described by Birch, an investigation has been made into the rate of production of sulphate from the organic matter in forest top-soils. This has proved to be a very slow process; for example, only 5 p.p.m. SO_4-S were produced from wattle forest topsoil kept at 30° C. under ideal conditions of moisture and aeration for six months and this in spite of high (350 p.p.m.) organic-sulphur content.

55. *The effect of elemental sulphur upon nitrification.* It is well known that adding elemental sulphur to a soil lowers the pH due to its oxidation to sulphuric acid. This reduction of pH usually favours ammonification

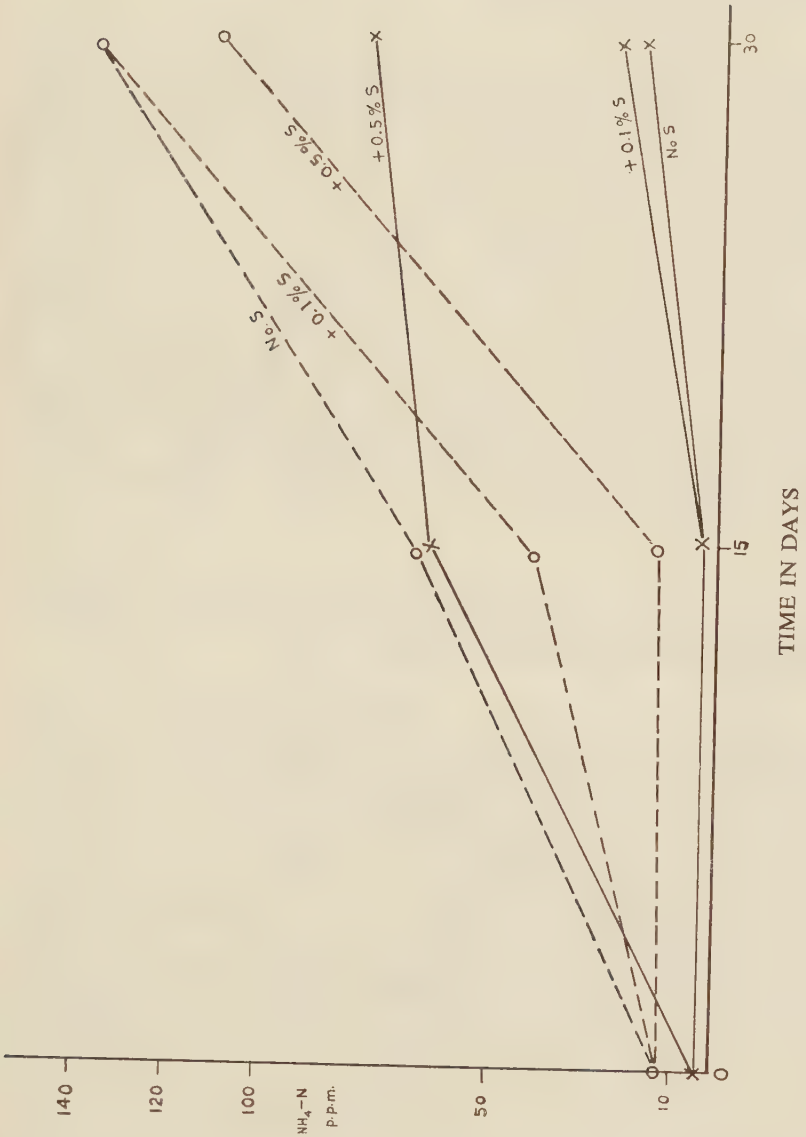

Fig. I. Effect of elemental sulphur upon ammoniafication in fresh and oven-dry Soil.
Complete lines represent fresh Soil.
Broken lines represent oven-dry Soil.

at the expense of nitrification unless the soil is alkaline when it may increase the rate of nitrification.

56. Experiments have been carried out using the soil from Muguga wattle forest and have shown that elemental sulphur added up to 0.5% increases both ammonification and nitrification. An interesting phenomenon was observed when the soils were oven-dried before treating with sulphur. Whereas the addition of 0.5% sulphur to fresh soil increased the rate of ammonification, the addition of sulphur to oven-dried soil (subsequently restored to optimum moisture) depressed ammonification (Fig. 1). After 15 days the inhibitive effect had disappeared and after 30 days the rate of ammonification was restored almost to its original level. As shown in Fig. 2, the sulphate production from the added sulphur would be greatest after 15 days and would be falling off after 30 days. Thus the effect of the sulphur would be less after 15 days either because the concentration of sulphate falls off or more likely, because possible toxic intermediate products of sulphur-oxidation have been completely oxidised.

57. No such anomalous results were obtained from nitrification measurements as oven-drying the soil resulted in increased rates of nitrification both with and without added sulphur.

58. *The effect of sulphur-containing aminoacids upon nitrification.* During the course of the investigation into the rate of sulphate production from soil organic matter, soils were incubated with various S-aminoacids. It was found that methionine added to 0.1% and incubated with soil for 15 days showed no breakdown at all to sulphate and during this time no nitrate was produced in excess of that initially present. The sulphur of cystine and cysteine on the other hand, was completely decomposed to sulphate in 15 days and nitrification was not inhibited. If the incubation of the soil plus methionine was continued for one month the methionine-sulphur was oxidised to sulphate and nitrification recommenced. It is a known fact that methionine inhibits the nitrifying organisms due to toxic intermediate breakdown products and only when the methionine itself is decomposed does normal nitrification become possible. It has not however, been fully realised that methionine can be produced from the vegetation; 0.3% dry wt. has been obtained from Kikuyu grass for example, and it was thought possible that the often reported fact of inhibited nitrification under grass cover may be due, at least in part, to the toxic effect of methionine.

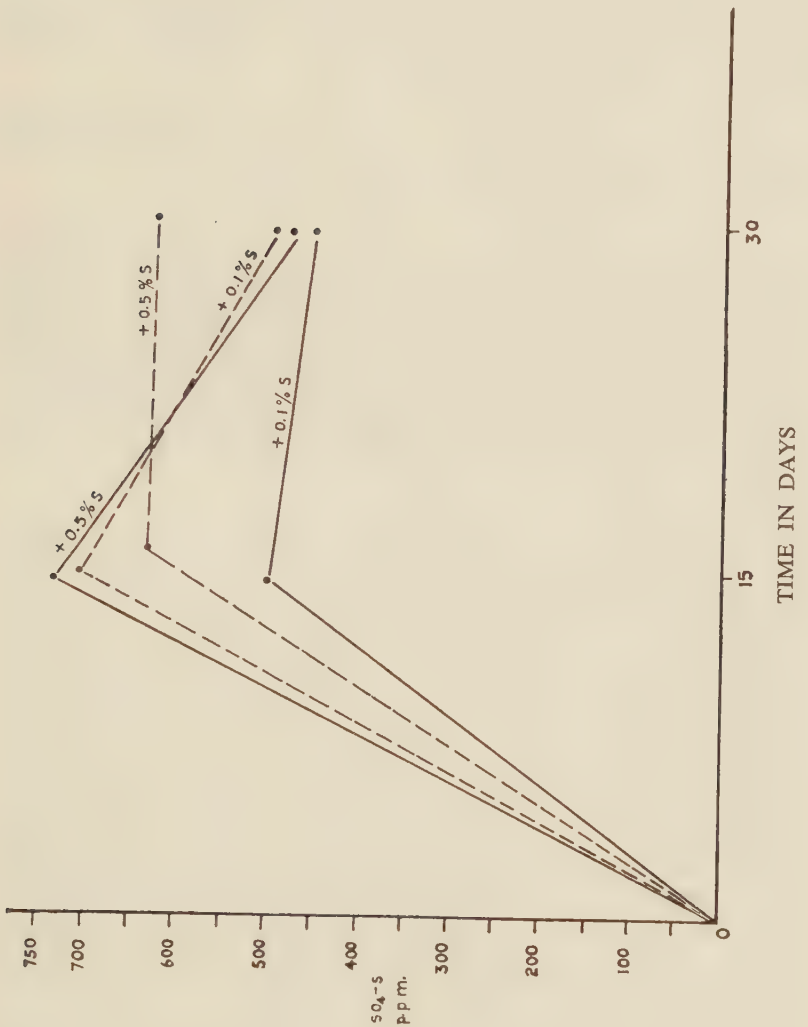

Fig 2. Oxidation of elemental sulphur added to soils.
Complete line represents fresh soil.
Broken line represents oven-dry soil.

59. Soil was perfused with ammonium sulphate solution, with ammonium sulphate solution containing a water extract of Kikuyu grass and with ammonium sulphate solution containing methionine. The results of this experiment are shown in Fig. 3 from which can be seen that after 14-20 days, nitrification, which had been inhibited by both methionine and Kikuyu grass, recommenced.

60. *Sulphur metabolism in the bottom deposits of Lake Victoria.* At the request of the East African Fisheries Research Organisation, some further work has been carried on on these problems.

61. As reported last year, the outstanding facts arising from the investigation into the distribution of sulphur in Lake Victoria were the very low sulphide contents and the correspondingly high organic sulphur contents of the lake bottom muds. With the co-operation of the East African Fisheries Research Organisation at Jinja a further and more detailed study has been made of the lake muds with particular reference to their rate and mode of decomposition. The investigation is being reported in the literature and the main conclusions are briefly reviewed here.

62. Sulphur is removed from the lake biologically by plankton and other plants and their dead remains are deposited on the lake bed where they accumulate. Thus one factor affecting the fertility of the lake is the rate of decomposition of these bottom deposits. As, even at depths of 15 metres below the mud surface, over 90% of the total sulphur present is in organic combination, it would appear that the rate of decomposition is extremely slow. Laboratory experiments have shown that although the sulphate already present in the muds is not anaerobically reduced, sulphate added to the overlying water results in the appearance of insoluble sulphides. Furthermore, it has been found that boiling, drying or washing with Morgan's reagent permits normal decomposition of the muds to take place. That is, after such pre-treatments the organic sulphur in the muds will be oxidised to sulphate on aerobic incubation or reduced to sulphide on anaerobic incubation. If the muds are filtered from excess water the organic sulphur is converted on subsequent decomposition to sulphate, albeit at a very slow rate. If, on the other hand, the mud is kept waterlogged then there is an unexplained loss of sulphate which is not balanced by the appearance of insoluble sulphides and which may be due to assimilation by micro-organisms.

63. A subsidiary loss of sulphate occurs by sorption on the muds. This has been found to take place when the silica fraction which accounts

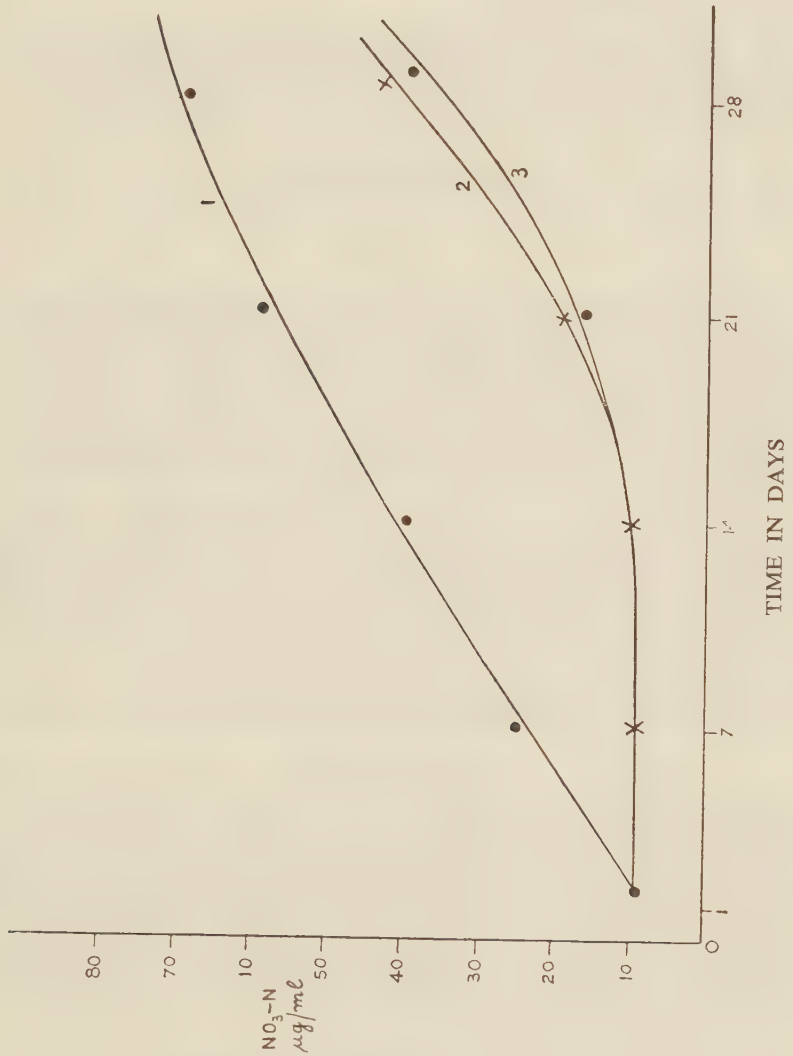

Fig 3. The effect of methionine and kikuyu grass upon nitrification in a soil.
1. Soil perfused with ammonium sulphate alone.
2. Soil perfused with ammonium sulphate and water extract of grass.
3. Soil perfused with ammonium sulphate and methionine.

for a large percentage of the muds is diatomaceous, for example at Pilkington Bay. In places where the silica fraction is predominantly sand, no such sorption occurs.

64. With regard to the present sulphur requirements of the lake, these must be met from the incoming streams as neither the rain nor the island soils add any appreciable amount of sulphur to the water.

SOIL MICROBIOLOGY

J. W. Millbank

65. During the greater part of the year the Microbiologist was working in the Soil Microbiology Department, Rothamsted Experimental Station, England, in order to obtain experience in modern techniques in Soil Microbiology. During this period, work was done on methods of estimating the numbers of nitrifying bacteria in soil, and a paper on the estimation of *Nitrosomonas* in soil and culture was published in *Nature*.

66. On arrival in East Africa much of his time has been devoted to setting up a laboratory and training an assistant in elementary bacteriological and assay techniques; at the same time some preliminary work on the rate of nitrification in various local soils, and the effect on the micro-flora of intense drying, has been done. The latter investigation was initiated in order to fill in gaps in the data obtained by Dr. H. F. Birch on the effect of drying and re-moistening of local soils.

67. In addition to work on the nitrifying bacteria, future work will also be directed to the study of legume nodule bacteria, the first investigation to be undertaken, in conjunction with the Chemistry Dept., being a survey of the locally occurring strains infecting lucerne. Any strain variation is to be correlated with analyses of the total carbon, nitrogen, phosphorus and mineral constituents of the host plants, in an attempt to explain the wide variations observed in size and apparent well-being of plants grown under what appear to be identical conditions.

ANALYTICAL SERVICES : CHEMICAL

M. T. Friend

68. This section has mainly been concerned with the analysis of soils and plants from various research officers and departments.

69. In all, 6,588 determinations were carried out on 794 soil and 761 plant samples, as follows:—

Soil Survey. 380 soil samples (110 profiles) from a survey of areas of Tanganyika Territory were analysed for pH, carbon, nitrogen, coarse and fine sand, clay and silt.

Fertiliser Schemes. 123 soil samples from fertiliser trials in Kenya and Tanganyika were analysed for pH, carbon, nitrogen, sand, silt, clay and three forms of phosphate.

Forest Department. 33 soil samples were analysed for carbon, nitrogen, phosphate and pH.

Plant Analyses. 761 plant samples, mainly from the above mentioned Fertiliser Schemes were analysed for nitrogen and phosphorus.

Miscellaneous Analyses. Six soils were analysed for the Soil Physics Section; 252 soils in connection with flour quality investigations; two deep profiles from forest pits at Muguga; 61 soils in connection with Organic Matter Studies and six fertilisers for N and P.

70. *Determination of Amino-Nitrogen.* Amino-N was determined on a range of pure aminoacids and on mixtures of aminoacids together with Dr. D. W. Duthie. Using the Pope and Stevens method which involves the determination of copper, the reagent *bis*-cyclo hexanone oxalydihydrazone was employed. It was found that a common copper/α-amino N factor did not apply to all the amino acids but the range of the factor diminished for mixtures of acids. For animal feeds a factor of 0.48 is suggested for copper/α amino N with the analytical method employed. A more complete account of this work is given by Dr. D. W. Duthie in the Animal Industry Section of this report.

ANALYTICAL SERVICES SPECTROCHEMICAL

G. T. Chamberlain

71. During the year the Section continued the routine analysis for bases by the Lundegardh flame method, and a total of 578 soils, 319 plants and 38 other samples passed through the laboratory. This total is smaller than the previous years at Muguga and the reduction is due mainly to more attention being devoted to trace element investigations.

72. The first samples for trace element analysis were completed in the last few months of the period covered by the previous Annual Report, and work has steadily increased to the extent that 121 plant samples and 54 soil samples were analysed. Details of the work carried out are given under the appropriate headings below.

73. Futher investigations on the method for direct reading potassium have shown that fatigue of the photo-electric cell caused

errors, but when these were removed the standard deviation between results by this method and the normal method was about 5% of content. An instrument is now being designed to incorporate a light for fatiguing the cell before use and keeping the cell illuminated between measurements.

74. Experimental work has begun on the use of the triggered arc source unit in conjunction with solution techniques. Two possibilities are being explored, the porous cup technique and a normal cup technique.

75. The Section was called upon to exhibit at the Nairobi Show of the Royal Agricultural Society of Kenya in October and at the Agriculture and Trade Show, Kampala, Uganda. The exhibit included the medium spectrograph; microphotometer and accessory equipment in working order to illustrate flame and arc methods, and the value to agriculture of spectrochemical methods of analysis was illustrated. Considerable interest was shown by the public.

76. *Bases in Soils, Plants, etc.* Of the 578 soil samples analysed, 417 were submitted by the Soil Survey Division of E.A.A.F.R.O. The majority of these were from soil profiles in the Southern Province of Tanganyika, but in addition samples came from the Usambara Mountains, Himo, Arusha and Longido in Tanganyika and from the Athi Plains, Ngong, Ol Joro Orok and Kitale in Kenya.

77. At the request of the Agricultural Officer (Pyrethrum) Kenya, exchangeable bases were determined in soil samples from phosphate fertilizer trials, laid down in some of the pyrethrum growing areas of Kenya. It was found that responses of the pyrethrum to phosphate followed the same trend as that which Birch found for wheat and grass, that is, soils of low percentage saturation of the base exchange capacity responded while the more saturated soils did not respond to phosphate fertilisers (see Table page 31),

78. For the Soil Physics section bases were determined in ammonium acetate and saturated paste extracts of soils from a potentially irrigable area of Tanganyika. Results showed that while a large quantity of bases were removed by the acetate very small concentrations were found in the water extracts, which supported the view that irrigation might be practicable.

Location	*% Saturation of B.E.C.*	*Increase in Yield (lb./acre)*
Kinangop	26%	200-400
Dundori	29%	100-200
Londiani	30%	200-400
Molo	42%	150-300
Ainabkai	50%	200
Kipkabus	56%	100
Londiani	71%	NONE
Mt. Meru	77%	NONE*
Mt. Kilimanjaro	80%	NONE*
Londiani	80%	NONE

*Statistical trials not carried out

79. In addition to the above, bases were determined in plant and soil samples from the Forest and Agricultural Departments, Kenya, as well as in all samples received for trace element analysis, and samples in connection with Dr. Birch's research.

80. *Trace Elements in Soils and Plants.* Two main lines of approach were adopted in this work, firstly that of building up a fund of data of the trace element contents of East African soils and plants, and secondly, the analysis of samples in which trace element deficiencies or toxicities were suspected. Liaison with territorial departments and other research laboratories has facilitated the analysis of a wide range of samples, and has brought to light many problems which might usefully be investigated.

81. A further 32 samples of flour were analysed as a continuation of the investigations into baking quality. Three varieties, "Kenya Settler", "Regent" and No. 184, were considered, but no confirmation was found of the indications that barium and manganese might be related to dough strength (Annual Report 1954/55).

82. Samples of lucerne, barley, canna, sunflower, potato, sugar beet, fodder beet, russian comfrey, lupin, sweet potato, kudzu vine, haricot bean, fiwi bean and various grasses were taken for analysis from the "museum" plots on the Muguga farm. Where possible, different parts of the plants were analysed separately, e.g. leaf, stem, tuber, seed, etc., and from the results it was found that corresponding parts of different plants, when grown in the same soil, differed to a remarkable degree. In leaf samples, copper varied from 2-50 p.p.m. (parts per million), vanadium from 0.02-1 p.p.m., manganese from 100-20,000 p.p.m. and in lupin seed, molybdenum varied from 10 to over 100 p.p.m.

83. This high molybdenum content of lupin was indicated in the feeding stuffs reported earlier. 19 samples of lupin seed have now been analysed, and in all cases high results have been obtained. Lupin seed from the Grassland Experimental Station, Kitale, contained 10 p.p.m. and wild lupin from the shores of Lake Naivasha had a content of 38 p.p.m. Experiments have been laid down at Muguga to discover whether (1) there is a relationship between lupin variety and composition, (2) green manuring with lupin affects the molybdenum content of a subsequent crop, (3) repeated cropping with lupin, can exhaust the available soil molybdenum.

84. Attention was drawn by the Officer-in-Charge, Plant Quarantine Station, to sweet potato plants which showed chlorotic mottling in the leaves. Analysis revealed that the degree of mottling was related to manganese content and that about 3,000 p.p.m. could be tolerated without damage, while severely mottled leaves contained about 9,000 p.p.m. Further work is being undertaken in an attempt to determine the conditions promoting the mottle.

85. At the request of the Coffee Research Station, Lyamungu, Tanganyika, nine coffee leaf samples were analysed. A suspected magnesium deficiency in one sample was confirmed, but this same sample also showed an exceptionally high copper content of 300 p.p.m., compared to 40-100 p.p.m. of this element in the other samples. Some unexpected results were obtained in other cases such as 1,000 p.p.m. iron compared to an average of 200 p.p.m. and strontium and barium being present in amounts of up to 600 and 200 p.p.m. respectively. Molybdenum was again of interest as the results for eight of the samples ranged from 0.6-3 p.p.m. (among the highest of any samples analysed so far) but the ninth sample contained 10 p.p.m. This sample, having pale olive green edges to the leaf and suspected of being Mg deficient, had a normal magnesium content.

86. Six other coffee leaf samples from manurial trials, received from the Coffee Research Station, Ruiru, Kenya, had copper contents generally similar to the Lyamungu samples, but their strontium and barium contents were only about half.

87. For the analysis of soils for trace elements, the extraction with 2.5% acetic acid has been used, this having been found suitable in the United Kingdom for determining available cobalt. This extraction is also proving suitable for East African soils. Other extractants are

being tried, particularly for the determination of molybdenum, acetic acid being unsatisfactory for this element.

88. Two samples each of *Cynodon dactylon*, *Chloris gayana* and *Vigna gracilis* and corresponding soils were analysed for the Animal Health Research Centre, Entebbe, Uganda, the results showing that the trace element contents of the soils were of similar order to richer soils and the plants contained what at the present time seem average quantities.

89. Nine soils were received from the Nakuru area to see if there were any differing trace element contents between soils from good and bad pastures. There was little difference between sites.

90. As a more fundamental study, the distribution of trace elements down soil profiles is being determined, and two deep profiles (to 20 feet) on the Kikuyu red loam at Muguga have been analysed. Both profiles were of forest soil, the first (A) being under black wattle on a well drained slope, the second (B) under gum almost at the bottom of a valley of comparatively poor drainage. Marked differences were observed in both content and distribution. Profile (A) showed that contents of beryllium, chromium, lead, nickel, tin, vanadium, and zinc dropped rapidly in the first three feet, and decreased further but more gradually with depth. Cobalt, on the other hand, showed an increase in content with depth, whilst titanium decreased with the first six feet and then increased. Profile (B) showed very little change with depth although such minor changes as there were occurred in the first two feet. Some marked differences in actual content of the trace elements in the two profiles were found, for example :—

	Profile A		*Profile B*	
	Surface	20′	*Surface*	20′
Beryllium	4.5 p.p.m.	0.9 p.p.m.	0.5 p.p.m.	0.6 p.p.m.
Chromium	0.7 „	0.2 „	0.1 „	0.1 „
Cobalt	0.05 „	0.2 „	0.06 „	0.06 „
Lead	1.6 „	0.6 „	0.6 „	0.5 „
Titanium	1.8 „	5.0 „	0.5 „	0.5 „

91. In addition to the base determinations, trace elements were determined in six of the soil samples from the phosphate experiments with pyrethrum already mentioned. Comparisions were made between

the soils of Mt. Kilimanjaro and Mt. Meru, where growth is good, and four areas in Kenya, (Molo, Londiani, Nanyuki, and Mweiga) where growth is poor. Noticeable differences between the Tanganyika and Kenya soils were observed in contents of cobalt, beryllium and vanadium, as is shown in the following table of comparision :—

	Mt. Kilimanjaro	*Mt. Meru*	*Kenya Areas*
Cobalt	2.2 p.p.m.	1.8 p.p.m.	0.15 -0.5 p.p.m.
Beryllium	0.2 „	0.8 „	3.00 -5.00 „
Vanadium	0.16 „	0.67 „	0.025-0.07 „

92. A sample of "edible earth" from Kitale was examined and this showed outstanding amounts of vanadium (11 p.p.m.). The cobalt content was also high (1.3 p.p.m.). More of these samples will be analysed in conjunction with the Department of Veterinary Services, Kenya.

93. Other samples analysed for trace elements have included five feedingstuffs (wheat, bran, fine thirds, common thirds and oats) from the United Kingdom, sorghum grain (weevil susceptible and weevil resistant) from Tanganyika, grass and tomato samples from Uganda and a Lake sludge from the East African Fisheries Research Organisation.

94. Development of a method for the determination of total trace elements in soils has commenced and it is hoped to complete this in the coming year. I wish to express my gratitude to Dr. L. W. Strock of Sylvania Electric Products Inc., U.S.A. for a gift of 44 grams of germanium metal in connection with this work.

95. An important point in technique came to light recently, for it has been found that the rapid changes of humidity which can occur in tropical countries may cause serious errors when using the concentration method unless precautions are taken. A series of experiments using hygrostats of 0 to 93% humidity showed that concentrates could take up, or give off, moisture sufficient in itself to cause errors of 10-20% should there be a change in humidity between determining the concentration factor and the internal standard content. The possibility of such errors occurring was eliminated by keeping the concentrates in a hygrostat from the time of preparation until completion of the analyses.

96. *Advisory Work and Visits.* Visits have been made in connection with co-operative work, or to give assistance on spectrochemical problems,

to the Kawanda Research Station, Animal Health Research Centre, Geological Surveys, and the East African Fisheries Research Organisation in Uganda, the Grassland Research Station, Mines and Geological Department, and Tea Research Institute in Kenya, and the Sisal Research Station in Tanganyika.

97. The visit to the Sisal Research Station was for a period of eighteen days to assist in bringing into working order their spectrochemical laboratory for trace element determinations, this being part of the programme of assistance given to the Tanganyika Sisal Growers Association over the past four years. The spectrographic equipment was checked and adjusted where necessary and trial calibrations carried out to ensure that satisfactory results could be obtained. Reagents and materials were examined, the main purpose being to enable the laboratory to be brought into operation with minimum delay. Portions of all the standard mixtures made at Muguga, covering the determination of beryllium, chromium, cobalt, gallium, germanium, lead, molybdenum, nickel, silver, tin, titanium, vanadium, zinc, barium, strontium, manganese, iron, copper, boron, calcium, magnesium, and sodium, were given to the Sisal Research Station in order to save the considerable time needed for their preparation.

98. An invitation was received to attend a Conference of Geological chemists from the three territories for a discussion on trace elements in geochemical prospecting. The findings of the Section were presented to the meeting and were a useful contribution to discussions on indicator plants. The members of the conference visited the E.A.A.F.R.O. spectrochemical laboratory and many details of technique were exchanged. Arising from the conference, delegates circulated lists of standard methods of analysis which were available in their laboratories.

SOIL SURVEY

G. H. Gethin Jones and R. M. Scott

99. Mr. Scott was absent on leave during the latter half of the year's work under review. In November Mr. Gethin Jones, as a delegate of the United Kingdom, attended the Second Meeting of the Council of the Interafrican Pedological Service held at Yangambi in the Belgian Congo. The Council endorsed certain recommendations made at the Second Meeting of the Interafrican Soils Conference (1954) which were related to I.P.S. activities, more especially the interchange of laboratory analytical

methods, pedological and agronomic studies of tropical black clays, and co-operative work aimed at ensuring uniformity in soil classification and nomenclature and the production of an agreed soil map of Africa. Separate soil survey exhibits were prepared and demonstrated at the Royal Agricultural Show at Nairobi, and the Trade and Agricultural Show at Kampala. A paper on Reconnaissance Soil Surveys, and their application to Land Usage, was given at the 1956 East African Soil Fertility Conference.

100. As the separate territories are now acquiring their own soil surveyors who will be able to undertake *ad hoc* soil and land use surveys, the E.A.A.F.R.O. surveyors have been able to give more attention to soil genesis, comparative studies of different concepts of soil classification, and the relative importance of the different criteria used. The basis of the system of soil classification employed remains the genetic one similar to that used by other African pedologists, but it is recognised that, up to the present, there has been a lack of uniformity in the classification and naming of soils. With the institution of the Inter-African Pedological Service, it will be possible to organise the collation of pedological data, and ensure more uniformity in soil classification and nomenclature, which is necessary for the ultimate preparation of the first soil map of Africa South of the Sahara.

101. *Soil Reconnaissance Surveys.* Essential tasks under East African conditions are soil reconnaissance surveys over extensive regions where there are few or no records of soil conditions. The purpose is to collect factual data about the kinds of soils that occur, and to study in the field the associated genetic factors which have given rise to such soils. This work makes possible the recognition of new soil classes, and a more complete small scale soil map. The field technique involves the taking of continuous notes of the changing soil conditions as seen *en route* from a moving vehicle, with stops as necessary to examine and describe representative soil profiles and to take samples of the above, and also of pedologically interesting deep soil sections which illustrate and elucidate particular soil forming processes. As the soil reconnaissance proceeds, many of the different kinds of soils noted can be given a tentative classification within an established framework. As the journey covers different combinations of geological, climatic and landscape conditions, new soil classes have to be allowed for. In the case of ancient land surfaces on extensive gently undulating peneplains, one task is to note the presence, if any, of different kinds of soil sequences or catenary conditions associated with a repeated pattern of relief with differential soil re-sortment and

changes in the soil water regime. In such cases, component soil units are not recorded as covering certain distances along the road as in the case of main soil classes, but as occupying relative topographical positions within a particular soil pattern. Following a comparative study of the collected representative soil profiles and other type samples taken elsewhere in previous years, and also making use of certain laboratory data, such as base saturation and organic matter content, the different sets of soil conditions are characterised, and the tentative classifications made in the field are confirmed or modified as found necessary.

102. An extensive soil reconnaissance journey, using roads and tracks as traverse lines, was made through portions of Tanganyika. The general route was down the coast to Lindi, westwards to Songea and the shores of Lake Nyasa, and then northwards through Mbeya, and Singida. Deviations were made through country of special pedological interest such as the Usambara and Uluguru Mountains the Makonde, Ubena, Mbulu and Iramba Plateaux, and the Bohoro, Bahi and Wembere depressions. The toal distance covered in six weeks of travel amounted to 4,200 miles. The Director of Agriculture, Tanganyika, had made comprehensive arrangements for the two soil surveyors to be met by a sequence of his field officers throughout the journey. It was thus possible to discuss the different kinds of soils noted and to obtain information on the general distribution of certain main soil classes.

103. Travel through new country has illustrated how apparently similar sets of soil-forming factors have generally given rise to soil classes already allowed for in the system of classification used, as summarised in last year's Annual Report. In some instance, some of the latter, which had been noted as odd occurrences only, were found to be extensive.

104. Some of the new kinds of soils noted, including those now found to be extensive, are listed below :

1. Lithologically-determined, cracking, black sandy clays to clays derived from calcareous Cretaceous sediments, including limestone, on slopes and hill-tops near the Coast.
2. Calcareous, heavy, Brown Plains Soils derived from volcanic tuffs under semi-arid conditions.
3. Calcareous, sandy Red Plains Soils formed by the further weathering of relict red mantle Plains Soils under semi-arid conditions.
4. Alkaline, grey, lacustrine soils made up of dark brown peds coated with finely dispersed calcium carbonate.
5. Youthful, dark volcanic soils with a pedocal trend of development.
6. Ando-like, high humic, juvenile, volcanic ash soil formed under cool, humid conditions.
7. Youthful, volcanic soils with a pedalfer trend of development.

8. Skeletal, shallow, brownish-grey, gritty, light-textured soils with much alterable minerals and showing no profile development, occurring immediately below rocky slopes in granite country.
9. Pallid, micaceous-kaolinitic soils without highly coloured sub-soil derived from gneiss on slopes subjected to long-continued geological erosion, such that further soil maturity is arrested.
10. Deep, grey-brown to brown loose sands near the coast.
11. Shallow, 'red earths' with deeper pockets derived mainly from coral.
12. Red and orange-red sandy soils which become heavier with depth, derived from siliceous Karroo, Jurassic, Cretaceous, Tertiary and later sandy sediments at low elevations.
13. Senile, low humic, (< 0.8% organic carbon), highly leached, yellow, floury clayey sands with a low amount of total exchangeable bases of the order of 1 m.e./100g. with a marked development of ferruginous concretions at depth, formed from ancient granitic 'mantle' material on peneplains (Miocene).
14. As above, with grey upper solum,
15. Shallow, grey, ground-water ferrallitic soils formed within volcanic ash laid on heavy sediments under conditions of poor drainage.
16. Light grey, slightly alkaline Planosols formed on gently sloping, heavy sediments.
17. Remnant humic (about 5% organic carbon), volcanic ash soils overlying an orange-brown soil with ferruginous concretions.

105. Some of the soils listed above under more general headings refer to soils within already established Great Soil Groups, but they have been formed under somewhat different conditions, and exhibit noticeable variations as compared with those previously recorded. Some examples are lithologically-determined, cracking black clays derived from calcareous sediments near the Coast, and ferrallitic-kaolinitic soils derived from different kinds of parent materials at low elevations. Youthful volcanic soils showing particular trends of developments were found to be extensive.

106. A major task has been the collection and sorting out of soil data from all sources, and the continuation of high category-small scale soil mapping. Though it is feasible to classify and mark boundaries along roads traversed, the difficulty is the reliable mapping of the unknown hinterland. When the geology and topography are similar, soil mapping can be extended, but otherwise this is not possible. The East African soil map is on a scale of 1:2,000,000.

107. *Peneplains and Catenary Soil Conditions.* Some of the soil classes which are dominant over extensive regions also occur as components of well-defined soil catenas associated with different sets of physiographic conditions with differential soil re-sortment and drainage. Not only do such components vary in kind and number according to the landscape pattern and the lithology of the parent material, but the proportions of the constituent parts that make up a particular soil catena can vary greatly according to the stage of peneplanation. Thus, during the early stages, until critical gentle slopes are attained, catenary

conditions are absent, except for the deposition of fine material within depressions. With age and alternating water-logging and drought without leaching, the latter often gives rise to cracking black clays. With more advanced peneplanation, there is the increased deposition of pallid coarser material on lower lesser slopes. With the further levelling of the land surface, upland areas with heavier, more highly coloured, mainly sedentary soils contract while grey and yellow sandy soils extend up the gentle slope. Under extreme conditions of peneplanation, all originally higher land is worn away with the elimination of the uppermost member of the original catena leaving a paler coloured, aggradated 'soil mantle' over most of the land surface. The original higher lands in granite country may be indicated by low piles of boulders only. Under these conditions soil catenas represent a moving intermediate stage between the original soil classes, associated with an immature landscape, and those of peneplains. In the new environment the 'mantle' material develops new profile characteristics, depending mainly upon the amount of alterable minerals present and the soil climate. There are instances, such as near Dodoma, where deep soil sections show a sequence of different kinds of further soil weathering, such as relict ferruginous concretions in a new calcareous soil. Strips of cracking, black sandy clays to clays survive though only a few feet below the general land level. Certain inconsistencies in the normal pattern of soil sequences usually result from irregularities in relief, and small differences in the nature of the parent material. Locally the general catenary pattern is disrupted by the re-dissection of an earlier soil pattern. There is always need to be on guard against misinterpreting catenary soil sequences, such as under conditions of short range visibility in woodlands when mid-catenary conditions may be noted where the track surmounts apparent high land, whereas in fact, there is still higher land off the track with the appropriate uppermost member.

108. The most common pattern of catenary conditions exhibits a reddish-brown surface soil over a heavier, redder sub-soil on high ground and upper slopes; a grey-brown more sandy soil over an orange-brown heavier material on middle slopes; then a deeper layer of a more greyish surface soil over a more yellowish sub-soil; and finally deep, grey, seasonally-wettish clayey sands indicating increasing degrees of reducing conditions on lesser lowest slopes. Locally, such conditions pass into cracking black sandy clays to clays which also receive materials in solution. A dark grey sandy loam covering often occurs along the margins.

109. Increasing stages of peneplanation with associated catenary soil conditions cover vast areas of the Miocene Peneplain in Central

Tanganyika. Extreme conditions with the development of mainly senile pallid soils with pronounced ferruginous concretions at depth occur on the almost level watershed between the head waters of the Kisigo tributary of the Great Ruaha, and streams flowing to the Bahi and Wembere Depressions. Senile peneplain soils of low inherent fertility are dominant over about 250 miles between Makongolosi and Singida. As a corollary to widespread occurrences of peneplain 'mantle' soils, primary ferrallitic-kaolinitic soils, which are mainly sedentary except for some creep down slopes and which only have concretions in drainage grooves, are associated with more youthful landscapes now undergoing slow geological erosion. Such soils are extensive on tectonically raised blocks of land within peneplains.

110. *Applied Pedology.* Basic data about the distribution of different kinds of soil can be used to provide a broad inventory of land resources, and to indicate the scope for development. Apart from the soil itself, there is need to take note of the present climate, the kind and vigour of the vegetation, the lie of the land and the ease of cultivation, and also the all-important question of the distribution of permanent water supplies. In many instances there will be need to study the agricultural properties of certain combinations of soils and climate. Observations in Tanganyika showed a very uneven distribution of the agrarian population, with probably more than half the total cropped and fallow lands distributed over less than a tenth of the land, and with at least half the territory almost uninhabited. It was noted that the uneven distribution is only partially related to soil conditions only. Other factors such as population pressure, good water supplies and, of course, reliable rainfall have often induced the cultivation of marginal soils: other factors have inhibited settlement where there are suitable soils. As indicated by rainfall reliability maps, there are very extensive regions where rainfall is too low and unreliable for settlements based mainly on crop production, hence there follows a low population density based on stock. Another factor at present limiting the extension of cropping suitable lands throughout large parts of Tanganyika was noted to be the lack of permanent domestic water supplies.

111. Particular sets of soil conditions were repeatedly found to be associated with underdevelopment, even when other factors were favourable. Firstly, there are various kinds of intractable, mainly altered sedimentary soils, which are too difficult to work when all cultivations have to be done with the hoe. Apart from the better known range of so-called 'black cotton' soil, some of which even during the short period

between being sticky and highly indurated are difficult to cultivate, there are lighter-textured, gritty, 'hard-pan' soils with some exchangeable sodium, and also pallid Cemented Plains Soils which readily pack and prevent water percolation.

112. A different set of adverse soil conditions comprises senile soils occurring either on elevated erosion surfaces, or else developed from ancient mantle material on extensive peneplains. These highly leached soils, derived from a wide range of original parent material, occur on sites where there has been no slow geological erosion with associated soil rejuvenation. The highly leached soils with pH values of 4.5 to 5.5 for the surface horizon, and more acid conditions at depth, have a highly unsaturated, low Base Exchange Capacity throughout the soil profile. The soil organic matter content is very low and confined to a shallow surface soil in the drier regions. In cases of extreme soil senility, such as in the vicinity of Itigi, there are greyish-yellow (10YR 5-4), weak crumbly clayey sands with loose, rounded, dark red and then pitted, platy, ferruginous concretions at depth. A shallow, low humic, surface soil has .5 to 1.0 me/100g. only of total exchangeable bases with less than ten per cent saturation associated with pH values of about 4.5 The sub-soil has still more extreme conditions. These impoverished soils carrying a specialised thicket are not cultivated, though there is close settlement on nearby rejuvenated sandy granitic soils. Under cool and humid conditions, highly leached, orange-brown soils derived from gneiss, granite and acid volcanics, though with a deep surface horizon (pH 4.5 to 5.5) containing up to 5% of acid humus, have less than 2 me/100g. of T.E.B. with about 5% to 15% saturation. Below the humic surface soil, material with 30% to 50% of clay has only 0.5 to 1 me/100g. T.E.B. with less than 10% base saturation. Such upland senile soils are widespread throughout East Africa and are frequently characterised by an originally forest vegetation changing to bracken after a short period under cultivation.

113. There are also little-utilised soils of low inherent fertility which have been derived direct from coarse siliceous sediments which were originally exhausted of clay forming minerals, bases and other nutrients during one or more previous cycles of weathering and deposition. Such conditions are extensive over the more elevated portions of Bukoban Sandstone, the more siliceous Karroo and Cretaceous sediments, and the Muhuwesi Sands. Present low soil fertility is a reflection of impoverished parent materials. These soils usually contain 90 to 95% of sand with only about 1% organic matter in a shallow surface soil, and negligible amounts in a slightly heavier sub-soil. With more clay

compensating for less organic matter, the soil profile has a fairly uniform low T.E.B. of about 1 me/100g. Such soils of medium to low inherent fertility are very extensive in Southern Tanganyika and are usually associated with a less vigorous growth of *Brachystegia* woodland.

114. *Tropical Black Clays.* Special attention has been given to the study of the genesis and properties of cracking, grey-black to black, sandy clays to clays—the so-called black cotton soils—which are extensive throughout East Africa and which, up to the present, have been little utilised except for extensive grazing. They are interesting in that though there are variations in their genesis, they have many basic properties in common. They are subjected to alternating conditions of water-logging and severe drought and, with continued drying, the formation of deep cracks up to three inches across. The washing in of surface material causes a seasonal kneading of the soil, thus bringing about very little profile differentation except for a gradually falling organic matter content and, when small lime concretions are present, these are more numerous at depth. Though always very dark in colour the heavy soil has relatively low values for organic carbon of the order of 1% to 2½%. The lower values are for more alkaline soils and those which contain sand originating from the parent material. The higher values are for soils subjected to less prolonged drought and those which diverge somewhat from true cracking black clays. Another common feature is that the soils have high values for Base Exchange Capacity, usually to the order of 45 to 55 me/100g. in the case of soils without much sand, and also a high base saturation of 80% or more. The calculated B.E.C. of the clay fraction of the sub-soil for soils with pH values above 6.5 amounts to about 100 me/100g. The proportion of exchangeable magnesium present is higher than for most soils and there is often some sodium which, when present, increases with depth. The soils, though seasonally wet, show no signs of mottling or glei formation.

115. On the other hand, there are differences in the manner of soil formation and a fair range of variation in certain soil properties. They can be lithologically or topographically determined, being derived direct from a range of hard metamorphic and sedimentary rocks, volcanic lavas tuffs and ashes, and soft limestones. They are also formed by the further weathering of pre-formed fine fractions, as in the case of lacustrine and old alluvial deposits. The soils vary greatly in age occurring on old land surfaces ranging from Miocene—including some on now elevated sites—to Pleistocene and Recent, mainly within depressions. They occur over wide plains extending over some hundreds of square miles,

as narrow strips in slight depressions between highly coloured sandy soils, on gently rolling landscapes, and they also occur as pockets on the same slope within red soils. They extend up steeper slopes in the case of a more basic parent material. In East Africa they occur from sea level to about 6,000 feet, under a present total rainfall varying from 20 to 40 inches—and occasionally higher—and on sites subjected to seasonal flooding. They also occur as relict soils in now much drier climates. They can vary in depth from some two feet only, when derived from hard rock on gentle slopes, to some six feet when they are definitely derived from deep, pre-formed clayey material. According to the nature of the parent material and the climate, they can range from slightly acid (pH about 6.2) to calcareous throughout and also alkaline especially at depth due to the presence of some exchangeable sodium. There may be only a few scattered small pellets of calcium carbonate or, in addition, a defined horizon of harder limestone concretions at the junction with the weathering rock, or a more diffused horizon within a clayey parent material. The soil colour when dry can range from black to grey-black (N 2/0 to N 4/0) and also with a shade of brown to 10 YR 3/2. While retaining essential general properties, there can be a range of soil texture from about 20% sand and 60% clay to 50% sand and 35% clay, and hence the use of the term 'grey-black to black, sandy clays to clays'. Another variation is the different degrees of cracking from slight only with the formation of a fine angular blocky (mainly 0.5 cm. to 1.0 cm.) surface mulch to the isolation of massive blocks of soil of about a metre across by deep and wide cracks. Differences in physical and chemical soil characteristics are reflected in cultivation properties and, with variations in the local climate and the risks of flooding, the agricultural potentialities of different soil variants and sites can vary greatly. The total extent of this major soil class in East Africa, which up to the present has been little utilized except for stock ranching, is likely to exceed 10,000 square miles. A particular site variation related to land usage is that this class of soil can be uniform or else confined to a honeycomb pattern separating slightly raised 'islands' with a different soil formed by the almost complete spreading out of relict termitaria. The soil pattern shows up well on aerial photographs as the contrasts are accentuated by differences in the associated vegetation. There are also 'gilgai' formations. Again, in gently rolling country, the higher land often has a lighter-textured cap of a brownish grey, compacted but non-cracking soil.

PLANT IMPROVEMENT AND PROTECTION

CASSAVA BREEDING

L. R. Doughty, D. L. Jennings and D. W. Gourlay

116. The breeding programme for 1956 was restricted to seventy-six crosses, of which seven attempted crosses to *M. cathartica* were unsuccessful. Twenty-five of these crosses had as their objective the production of virus resistant, bitter types, unpalatable to pig. The remainder were still seeking for enhanced resistance to mosaic and Brown Streak.

117. *Field Trials.* Resistance trials of 440 clones from the '53 series of crosses, at the Sisal Research Station, Mlingano, were harvested in August. Twenty-four of these clones were selected for planting in a further trial, planted in November, as they appeared to exhibit a very high degree of resistance to mosaic and brown streak viruses. Most of these selected clones were from either intercrosses of third back cross (B3) derivatives from ceara × cassava hybrids or between B3 derivatives of ceara and dichotoma. Clones of the '54 series of crosses were also planted at Mlingano in November. Two hundred and twenty of the most promising were planted direct to replicated resistance trials, and 1,763 clones to a preliminary elimination trial.

118. The rains at planting time were sketchy but a good strike was obtained. Subsequent late rains around the end of the year enabled these trials to make steady progress.

119. The plucking technique (disbudding) described in the last Annual Report (p.37) has again been used and apparently it is equally effective though the trials are still incomplete.

120. A second trial of clones selected from the '53-'54 resistance trials was harvested in February. None of these clones was superior in all respects to the best hybrids already distributed, (these were used as controls), but a few gave slightly better performance in respect of either mosaic resistance or brown streak resistance or yield. As has been noted before in these longer term trials, a considerable number of plants that had had symptoms of mosaic did not produce these symptoms again in the shoots developing after the cold weather dormant period.

121. *Quarantine and Distribution.* Recommendations for the limited distribution of cuttings from Amani to inland areas, with suitable

precautions against Brown Streak dissemination, have been made by the Specialist Committee on Agricultural Botany. Arrangements have been made accordingly, and the first consignment of cuttings has been dispatched to Kakamega. This consignment consisted of a wide range of types whose resistance to mosaic was not always high enough for the severe conditions experienced on the coast, but was thought to be adequate for up-country districts where mosaic is less severe.

122. Recent trials in the Amani area have indicated that a high proportion of seedling progeny from certain parents possess this level of resistance. The possibility of distributing seed, instead of cuttings, to inland areas is therefore being considered. This would have the advantage that a wider range of material could be sent for testing in the environment in which it is to be grown, without any danger of spreading the Brown Streak virus.

123. The possibility of eliminating Brown Streak virus by heat therapy has been investigated at Muguga and Amani. At Amani, tests over a wide range of time and temperature combinations, using material which showed varying intensities of the disease, have shown that the virus is not eliminated by any combination of time and temperature, which is not lethal to the cutting.

124. No further distributions have been made to coastal areas during the year, but selections from the 1953 clones have been bulked and will be distributed later this year.

GROUNDNUTS

D. L. Jennings

125. Preliminary investigations into the possibility of using artificial embryo culture for interspecific hybridisation were begun. The initial experiments were not successful and this work will unfortunately have to be discontinued.

APPLICATION OF THE BRIEGER METHOD TO MAIZE BREEDING

L. R. Doughty and T. Graham

126. The study of the Brieger method for maize improvement continues, and has now reached the stage when we have material for

yield trials. The number of top cross lines under test is five hundred and two. Three hundred and forty-seven of these have originated from Nyanza maize, and one hundred and forty-two from Katumbili from the Lake Province, T.T. The remainder is yellow maize.

127. Some eight hundred and forty lines are still maintained for breeding work, most of these reaching the third inbred stage this season. From now on the breeding and selection work will diminish, and the emphasis will be on field trials of the material already available, and the building up of bulk stocks of the leading lines for more extensive yield tests in comparison with local maize.

128. This season we are again responsible for two of the co-operative variety trials carried out interterritorially under the auspices of the Specialist Committee on Agricultural Botany. This year the two trials are at Eldoret and Kakamega, the latter being made in collaboration with the Department of Agriculture, Kenya.

129. In view of the number of field trials to be hand-planted this season, an early start was made; planting commenced on the 19th March. Thereafter the early rains were quite adequate, and all the maize got away to a good start. Our hopes of a fair distribution of rain through the drier period, to be expected sometime between end May and end June, were not however fulfilled, and some of the maize had a fairly severe set back. In the latter half of June the rainfall had been adequate, but there had also been a certain amount of hail damage. The Kakamega trials have had adequate rain, and have made excellent progress. There is however, the prospect of high winds and hail causing damage here later in the season.

130. The yield history of the inbred material has been one of declining yields from the S1 to the S3 generations, as is to be expected. The S3 top crosses and those of the intra-family crosses in the S2 now in yield trials have however a very uniform appearance to date this year and, in the vegetative phase, there are no lines that are outstandingly better than others. There are however outstanding differences in drought resistance in families of Nyanza maize in the S3 generation that are to be top crossed this year.

INCORPORATION OF STREAK RESISTANCE INTO MAIZE

L. R. Doughty and T. Graham

131. There has been a serious deterioration in the germination of the older material ('52 and '53) of Peruvian origin which had to be kept

in store for the past twelve months, as we were unable to carry on this work last year. This year's work is therefore being concentrated on the testing and maintenance of the resistant lines derived from the 1940 and 1941 series of inbreds raised at Amani.

132. In addition we have again planted the F1 hybrids of Katumbili × Peruvian maize for further breeding. Last season these were rendered completely sterile by stem borer attack mainly due, we think, to the late planting of this material. To date this material is doing well.

THE AMERICAN RUST DISEASE OF MAIZE CAUSED BY *PUCCINIA POLYSORA* UNDERW.

H. H. Storey and A. K. Ryland

133. During the year progress in incorporating rust resistance into locally adapted maizes reached a crucial stage, and demonstrated that, subject to certain conditions, a successful outcome is assured. Primarily this has been the work of plant breeders in the Tanganyika Agricultural Corporation and in the Kenya and Uganda Departments of Agriculture. Full accounts will be found in the reports of these several organisations; but the part played by E.A.A.F.R.O. justifies reference to it in this Report.

134. A brief historical review of the research leading to these results follows. In 1951 information reached East Africa concerning the devastating outbreaks in West African maize of *Puccinia polysora*, a rust fungus then new to Africa. The Specialist Committee on Agricultural Botany thereupon planned in outline the research desirable in East Africa; the basis of this plan was the assumption that genetical factors for resistance would be found in the maize of tropical America. Here *Puccinia polysora* had been known for many years, but no serious damage had been reported; consequently it was thought that natural selection, during years of exposure to infection by this rust, might have caused resistant types to emerge among the American maizes.

135. It was not possible to put this plan into operation until, in mid-1952, *Puccinia polysora* made its expected appearance in East Africa. Thereupon E.A.A.F.R.O. undertook to import and to test American maizes. Consignments of seed were received in 1953 and early 1954 from the following correspondents, whose co-operation provided the foundations on which our work has developed :—

6 (from Mexico) through Dr. W. R. Stanton, West African Maize Rust Research Unit, Ibadan, Nigeria.

19 from Dr. L. M. Roberts, The Rockefeller Foundation, Estacion Agricola Experimental, Medellin, Colombia.

9 from Dr. A. J. Ullstrup, Purdue Agricultural Experiment Station, Lafayette, Indiana, U.S.A.

118 from Dr. W. L. Brown, through Director, School of Tropical Agriculture, Trinidad.

51 from Mr. Mario Gutierrez G., Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica.

136. Earlier E.A.A.F.R.O. reports have described the methods of testing for rust resistance developed at Muguga and some of the results obtained. Whereas 68 African varieties and lines of maize—from East Africa, Rhodesia, Nyasaland and the Union—proved all to be fully susceptible, many resistant plants were found among the consignments from America. The E.A.A.F.R.O. work demonstrated that factors for resistance were inherited and indicated the manner of their inheritance. It also provided basic material carrying these factors from which resistant production types of maize could be bred.

137. First distributions of resistant maize seed to plant breeders in the territories took place in 1953. Thereafter practical field breeding rested with them, and E.A.A.F.R.O.'s part was confined to the provision of new information and some material emerging from its research. But at the end of 1955 the breeders had so far advanced that they were able to send to Muguga samples of their maize lines for resistance tests in our glasshouses.

138. Mr. J. S. Hemingway, at the Tanganyika Agricultural Corporation station at Nachingwea, had undertaken to transfer resistance into the local maize variety, *Katumbili*. Sixteen of his inbred families were tested early in 1956; all but one of these proved to be carrying resistant genes in the pure state and these were fully resistant to the only race of *P. polysora* known as yet to occur in the field.

139. Eighty-eight families were received from Mr. H. C. Thorpe; these had resulted from field breeding by himself and colleagues in the Kenya Department of Agriculture at stations on the coast. They were second-selfed families from crosses of selected resistant plants by several local maizes; they had not been tested in the field and the pure lines

picked out. The Muguga trials showed that 33 of the 88 families were almost certainly pure for resistant factors. We were able to complete these trials in time to allow Mr. Thorpe to plan his planting programme for 1956, which in consequence could be confined to the pure lines, with much saving of labour and space.

140. During this period we also tested in our houses nine maize lines on behalf of the West African Maize Rust Research Unit.

141. Unfortunately the testing of the above material occupied the whole of our available space during the critical two-an-half months, and we were unable to carry out tests on similar material bred at the Uganda Department's station at Kawanda. We provided Mr. B. J. T. Baldwin, however, with details of our testing techniques, and understand that he was able to type his material himself.

142. It must be regarded as extremely satisfactory that the Muguga trials have thus fully substantiated the work of the plant breeders. There was always the risk of a breakdown in the field work of selection for resistance, due to technical causes that could not have been foreseen. The evidence now available has demonstrated the practicability of breeding for resistance at the chosen stations; it has also afforded testimony to the thorough manner in which the work has been carried out by the officers concerned.

143. In an earlier paragraph we stated that the success of the practical breeding programme seemed to be assured, but subject to one condition being fulfilled. This condition is the continued stability of the rust to which our maize is exposed. In our 1955 report we recorded the appearance of a new physiologic race of *P. polysora* in our glasshouses; to this race some of our best resistant lines proved to be susceptible. There is still no evidence that this race (designated "EA. 2" in distinction to the "EA. 1" which is believed to be that prevalent in the field, and is the one with which all our early experimental work was done) has appeared at any of the field breeding stations. The risk that it, or other physiologic races, may do so however, constitutes a continuing menace, that might force us to re-institute a genetical programme *ab initio*. During the next year or two the new resistant varieties will pass from the breeding stations into general cultivation; it will be necessary to maintain a careful watch for any breakdown in resistance. If this occurs, E.A.A.F.R.O. will be in a position to attempt to type the rust race responsible, by using its genetically pure lines that have been derived from different sources.

144. Apart from tests on plant breeders' material, E.A.A.F.R.O. has continued its genetical research generally on the lines set out in earlier Reports. There has been some slowing-up in rate of progress owing to shortage of staff: Dr. Storey was acting as Director of the Organisation for five months, and Mrs. Ryland was absent on overseas leave for seven. At certain difficult periods Mrs. R. B. Gibson, while continuing her work in the administrative office, gave valuable assistance, without which critical material and evidence might have been lost.

145. Nevertheless, during the year some 800 separate experiments were completed in the glasshouses, and 150 pollinations made of selected plants from these experiments. The main purpose of this recent work has been to obtain a better understanding of the genetics of resistance. The establishment of Race EA. 2 of the rust, menacing though it has been to the practical problems of control, has proved an invaluable tool in genetical studies. At first our experiments were thrown into chaos since the two races were intermingled in our rust stocks; but we were able to separate the two and by adopting stringent precautions to maintain them pure.

146. The first conclusion from studying the differential behaviour of our maize lines to the two races was that we were dealing not with a single major gene, but with at least two. Certain maize lines derived from No. AFRO. 29 ("Colombia 2" variety) carried a gene that conferred nearly complete immunity from Race EA. 1 but complete susceptibility to EA. 2. Other lines from AFRO. 29, and from AFRO. 24 and 27 (ex Mexico) carried a gene, or genes, giving high resistance to both races equally.

147. Recent work has been directed to studying the interaction of two genes in hybrids between pure lines carrying each, in the hope of deciding their genetical relationships. It is too early to report any firm conclusions; but results are emerging of considerable fundamental interest and we hope during the forthcoming year to present for publication a paper on these genetical studies.

148. The present state of this co-operative research in plant disease control can be summarised as follows. Field breeding of locally-adapted maizes resistant to Rust Race EA. 1 is now well advanced in all three mainland territories; and much of this material is also resistant to Race EA. 2 should it appear in the field. Genetical studies at Muguga, on the resistant factors obtained from some of the more important of our

introductions, are nearing final conclusions; and a different form of reaction to infection found in certain N. American lines is under study. We have many pure lines of maize carrying one or other of the two genes for resistance so far recognised; and we propose to expand this collection in a search for other possible genes and to have at hand a larger range of test-lines available for typing any suspected new rust races that may be reported in the field.

149. Meanwhile E.A.A.F.R.O. has maintained close liaison with Departmental officers engaged in rust research, by personal visits each way and by the issue from Muguga of a series of Roneoed progress reports. Eight such reports from E.A.A.F.R.O. have been circulated to members of the Specialist Committee on Agricultural Botany, to official organisations in the United Kingdom and to certain other correspondents overseas. From time to time further lots of seed of resistant maize lines have been despatched to workers in the mainland territories and Zanzibar; and also to Southern Rhodesia, Nyasaland, Nigeria, Dahomey, Madagascar, Mauritius, India, Ceylon and Malaya.

VIRUS DISEASES OF SWEET POTATO

F. M. L. Sheffield

150. It is expected soon to bring to a close the study started four years ago of a stunted or mottled condition of Sweet potato. Diseased plants were shown to be infected with virus and the virus seemed to exist in a number of forms. As, on most Sweet potato varieties, symptoms differed only in degree of severity, these were at first thought to be strains of a single virus. I was, last year, able to report that these forms had been divided into two groups with different insect vectors. Group A, which causes a relatively mild disease, is carried by Aphids (*Myzus persicae* [1]) whilst group B, which ranges from very mild to very severe forms, is transmitted by white fly (*Bemisia tabaci* Genn. [2]). In most Sweet potato varieties, A is indistinguishable from the less severe forms of B. In order to have known virus-free stocks for experimental purposes, clones had been developed here from Sweet potato seedlings. That known as "Muguga C" seems to be a differential host of the two groups: in it, A causes numerous very small discrete chlorotic spots whilst group B induce a small mosaic pattern of greater or lesser severity.

[1] Identified by Dr. V. F. Eastop when working at E.A.A.F.R.O.
[2] Identified by Dr. L. Russell of U.S.D.A. Washington, D.C.

151. When white fly, previously fed on Sweet potato infected with B, were allowed to feed on "Muguga C" plants infected with virus A, many of the latter developed mosaic symptoms in addition to the chlorotic spotting. When white fly, already fed on a plant infected with a severe form of B, were transferred to plants carrying a mild form of B, there was no increase in the severity of the disease in the latter. It seems that infection with A affords no protection against infection with B but that mild forms of B do protect against infection with severe forms. It is therefore concluded that A and B are distinct viruses and that the latter exists in a number of strains. It was thought that A might be identical with "feathery mottle" virus of Sweet potato described from U.S.A. but the latter can be transmitted mechanically whilst all attempts to transmit virus A by this method failed. Severe forms of B sometimes cause the production of small greyish areas in tubers which have been kept. This may be the "corky spot" disease found in America.

152. Some virus diseases have a very wide host range including plants from many Natural Orders. In the case of a virus affecting an economic or food crop, it is important to identify these alternative hosts: they are often weeds or ornamentals which, if not eliminated, act as a focus of infection allowing a virus to persist in an area from one growing season to the next. It is also desirable to find out whether these Sweet potato viruses are identical with viruses described in other hosts. Search has therefore started for alternative hosts, both those which might become naturally infected in the field and also amongst certain recognised test plants usually used in the identification of viruses.

153. The plants most likely to be alternative hosts are those most closely related to Sweet potato: tests were therefore first made on some *Ipomoea* species[3]. *I. alba* L., *I. purpurea* L. and an ornamental allied to the latter have all been infected with virus A by grafting. Virus B has been transmitted to these same hosts and also to *Petunia* sp. by grafting with scions from infected Sweet potato, by the use of the white fly vector and also mechanically. *I. alba* is an almost symptomless carrier of both viruses. Cuttings from an apparently healthy plant of *I. learii* Paxt., which came from Amani often showed what appeared to be virus symptoms. Tests suggested that the original plant was naturally infected with virus B.

154. Mechanical transmission of B is difficult and all attempts to transmit it by this method to Sweet potato have failed, although the

[3] All *Ipomoea* sp. were identified by Dr. B. Verdcourt of East African Herbarium.

inoculum was obtained from all possible host plants and various techniques were tried. It can however be transmitted to the alternative hosts even if the inoculum is obtained from Sweet potato.

155. White flies are known to be the vectors of viruses attacking Abutilon, cotton, cassava and tobacco. Of these diseases only Leaf curl of tobacco and Cassava mosaic have been reported in East Africa. Cassava mosaic and Sweet potato virus B show many similarities and the two diseases often occur together in the same native plantations. However, in some experiments, virus B was not transmitted from Sweet potato to healthy cassava by the *Bemisia tabaci* vector of B, nor, using the same vector, was Sweet potato infected with Cassava mosaic.

156. *Attempted Therapy of Virus Diseases.* When plants are propagated vegetatively, any virus infecting them will be passed to their progeny. It is sometimes possible to cure the disease by holding the propagating material at a fixed temperature for a certain time. Attempts were made to inactivate virus B in tubers from infected Sweet potatoes by (1) heat treatment in a moist atmosphere, (2) by hot water treatment and (3) by chilling. For the heat treatments a range of times and temperatures were tried and chilling was done at 4° C. for various numbers of days. In all cases the tubers were killed before the virus was inactivated.

157. Similarly, no success attended efforts to cure Brown streak disease of cassava by heat treatment in a water bath.

FORESTRY

SILVICULTURAL RESEARCH

A. L. Griffith

158. As last year, work has in general continued on the long term lines laid down for us in 1952. The main emphasis during the year was on the Information Section, softwood problems and the development of Muguga estate for nursery, short term and long term experimental work.

159. Mr. Stuart (Silviculturist) went on long leave in January, 1956, prior to transfer to the Kenya Forest Department, and Mr. P. Howland (Forester) arrived in December, 1955, from the U.K. Forestry Commission.

160. The Silviculture Specialist Committee held its third meeting at Muguga in February, 1956. This meeting was largely a stock-taking of what had been done as a result of the previous two meetings. Particular attention was paid to seed orchard work, termite damage in young plantations, further standardisation of research procedure, and the progress of the interterritorially replicated experiments.

161. The third Forestry Course was held in November, 1955, and was attended by 18 officers, so that now 52 forest officers and foresters have been to the course. We were particularly glad to welcome one delegate from British Somaliland, and another from a private mining company of Tanganyika. An innovation of this course was that of holding the second half at Molo in the Londiani division of Kenya to study softwood tending. We are very grateful to the Chief Conservator of Forests, Kenya, for this facility.

162. The Tanganyika Forest Ranger Class from the Tengeru Natural Resources School spent a week with us in September, 1955. The section headings of the following report are those of the long range programme as approved by the E.A. Advisory Council in 1952.

I. INFORMATION SERVICES

163. During the year the E.A. Forest Bibliography was published. Three new E.A.A.F.R.O. Forestry Technical Notes were issued. All three were prepared by Mr. Stuart. These were No. 4 "Muguga Arboretum", No. 5 "Standard Forms and covers for recording and filing

experimental data and general information", and No. 6 "Short term planting-out experiments". Many inquiries were received and answered. The Forest Bureau was maintained and expanded and now contains 1868 Specific Ledger Files and 856 General Ledger Files. A new request of the territories that the highlights of information ledgered should be listed and circulated, is being carried out to the best of our ability.

II. STANDARDISATION OF RESEARCH PROCEDURE

164. It is now six years since forest research was organised on an East African basis. As a result of the experience gained during this period the Silviculture Specialist Committee discussed the subject and decided on some modifications of the Indian procedure which was adopted as a basis for a start.

III. RESEARCH ON SOFTWOODS

165. This report covers investigations at Muguga in which Dr. A. L. Griffith, Mr. B. E. St. L. Stuart, Mr. W. B. May and Mr. P. Howland have all collaborated.

A. Seed problems

166. (a) *Cupressus lusitanica* progeny trials. The three plots in the arboretum planted in 1952 have been replaced by replicated plots. These are now two years old and so far show no appreciable differences in height growth or vigour from stock of (1) five different sizes of seed and (2) three different cotyledon numbers (2, 3 and 4) from each parent tree. Within each treatment there are however, differences in colour and form and these are being watched.

(b) *Seed orchards.* Considerable discussion has gone on during the year by the various authorities concerned on the dangers of, and the precautions necessary for, the importation of elite material for grafting from outside East Africa, particularly with *P. radiata*, which is often of poor form and a very shy seeder. Mr. May has worked out a successful technique for grafting mature cuttings of both *P. radiata* and *P. patula* on to 18-month old saplings of their own species using side grafting, and has obtained 50-75% successful unions.

B. Nursery problems

167. Experimental work in the nursery at Muguga has continued. An account of the results of the last year's work combined with that of previous work is given below. In a number of cases results are so far not consistent and much further repetition is required. The variations may be due to the varied weather experienced in the past few years. Only 1952 (36.6 inches) gave a total rainfall near the average (36.4 inches). 1951 and 1954 (57.3 and 47.4 inches) were above average, and 1953 (22.5 inches) and 1955 (30.0 inches) well below average. It is noteworthy that the rainfall of 1955 although well below average in total was very well distributed and hence the planting "take" and subsequent growth were good. 1956, so far, after abnormal rain in January is still well below average.

168. *Soil mixtures.* No further work was done. The experiments of the past four years have shown the best results with "Muguga Standard Mixture" which consists of :—

Forest soil . . .	5 parts
Clay	1 part
Peat	2 parts
Rotted horse manure .	1 part
Crushed stone . .	1 part

with the addition of a "basic" quantity of N.P.K. to ensure that the essential nutrients are present. This "basic" N.P.K. consists of three parts sulphate of ammonia, three parts double superphosphate and one part of muriate of potash, and is used at the rate of 3 oz. per sq. yard of bed or half ounce per box of approximately 50 plants.

169. *Comparison of different pine soils.* Work of the past four years has shown that under Muguga conditions the addition of pine soil is not neccsssary in the nursery and that a good balanced soil mixture (Muguga Standard Mixture which contains basic N.P.K.) has produced better plants than boxes with a pine soil inoculation. It is the soil structure and the soil nutrients that have the greater effect. As the result of this an experiment was started in 1954 to compare the results obtained with pine soils from under the oldest pine plantations of different species from different places. The soil used was that of the first three inches of the forest floor below the undecomposed litter from *P. patula* and *P. radiata* stands at Kinale and Kitiro. Survival percentages were high

and varied from 87% to 100%. The experiment needs further repetition, but the two years' results so far indicate that the two species used (*P. patula* and *P. radiata*) do not show preference for their own soils (i.e. for possibly specific mycorrhizae) at all events under Muguga conditions but that the four soils used are merely of different qualities.

170. "*Mycorrhizal brew*" *experiment.* Last year's experiment was repeated with the same soil but "topped up" with a little fresh Muguga Standard Mixture. It confirmed the previous result that (a) no benefit or deleterious effect resulted from the brew and (b) there is no indication that *P. patula* prefers a *P. patula* "brew" to a *P. radiata* "brew".

171. The main interest of this repeated experiment was that using the same soil in the second year even though it was "topped up" with some new Standard Mixture only produced plants of roughly half the height of those in other experiments.

172. *Fertilisers.* The experiments described in last year's Report with *P. radiata* seedlings were repeated. N.P. and K. were applied in all combinations and at two rates which were :—

Fertiliser rate 5.	N.	Sulphate of ammonia 540 lb. per acre or 8 gm. per box. (Soluble N. found on analysis to be 20%).
	P.	Double superphosphate of lime 540 lb. per acre or 8 gm. per box. (Soluble P_2O_5 on analysis found to be 39%).
	K.	Sulphate of potash. 270 lb. per acre or 4 gm. per box. (Soluble K_2O found on analysis to be 52%).
Fertiliser rate 10.		Twice the above quantities.

The experiments confirmed the general indications previously obtained i.e.

(*a*) The response to the fertilisers varies with annual rainfall, being greater (about 33%) in a normal to wet year than in a dry year (about 10 to 15%).

(*b*) There is very little difference in response between the "5" and "10" rates of application, and hence the latter rate is unnecessarily high.

(*c*) The effect of application of fertiliser 12 weeks after pricking out is very small compared with application six weeks after pricking out.

(*d*) The pine seedlings gave the largest response to the nitrogen fertiliser and the smallest to the potash but the best plants were those given nitrogen, phosphate and potash.

(*e*) All the experiments made in the last five years have shown that the application of a basic quantity of N.P.K. is a very well worthwhile insurance. The quantity used is small, 3 oz. per sq. yard of bed or half ounce per box, but it ensures that the basic nutrients are present.

173. The above experiment is this year being replicated interterritorially with about 16 replications in the three territories.

174. *Organic and inorganic fertilisers.* An experiment was carried out during the year to test if tree seedlings responded better to organic fertilisers, whose nutrients were likely to become available over a period of time, than to inorganic. The organic fertilisers used were dried blood and hoof and horn as nitrogen sources, and bone meal as a phosphate source (though this probably contained a certain amount of nitrogen as well). The levels of application were approximately the same as in the preceeding experiment, and the plants were seedlings of *P. radiata* and *P. patula.* The results of this first experiment, in a rather dry year, were that the organics gave the same growth response as the inorganics. The levels of nutrients applied were however probably so high that they fell on the flattened part of the response curve, so a differential response would be difficult to measure.

175. *Minimum fertiliser requirements.* The experiments described show that the two levels of application have produced the same response. An experiment has therefore been started to measure the response of seedlings to lower rates of fertiliser.

176. *Date of sowing.* The experimental work, started in 1952 to determine the effect of different dates of sowing on the resulting plants, was continued with monthly sowings of *P. patula.* The stock raised is planted out about April of the following year in short term experiments to observe the subsequent behaviour of the various sizes of stock and this aspect is described in the first experiment of Section C. The experiments show a big drop in height growth of nearly 50% between pre-long-rains and post-long-rains sowings. This is most marked with *P. patula.* With *C. lusitanica* and *P. radiata* mean height growths of 12 to 14 inches and of about 12 to 13 inches respectively can be obtained with post-long-rains sowings. This is not so with *P. patula* and even

pre-long-rains sowings do not produce a plant more than 8 to 11 inches. It should be remembered that pre-long-rains sowing greatly increases the size and cost of a nursery and if the short term planting out experiments continue to show that we need the larger *P. patula* plants we will have to look for other nursery treatments such as wider spacing, shade, deep beds, fertilisers, etc.

177. *Effect of time between germination and pricking out on subsequent growth and survival.* This project was started in 1953 and seedlings of *C. lusitanica*, *P. patula* and *Eucalyptus saligna* were pricked out from the same seed beds 2, 5, 8, 11, 14 and 17 weeks after germination. The really early pricking out (as early as two weeks after germination) produced the best results and in general, the longer the delay, the greater the check, and the poorer the subsequent growth.

178. In the experiment of 1955 (measured this year) with *P. radiata*, *C. lusitanica* and *Eucalyptus saligna* the pricking out was done at weekly intervals for 14 weeks. With *E. saligna* and *P. radiata* the best results were obtained with plants pricked out one week after germination. With *C. lusitanica* the best results were the plants pricked out from one to three weeks after germination. These results clearly show a serious defect in our past nursery work i.e. that of late pricking out. This early pricking out needs skill and care and the seedlings must be handled by the cotyledons or young leaves as any rough handling by the stems at this early stage can cause serious losses.

179. *Use of wood preservatives on transplant boxes.* The experiments started in 1953 to study (a) the lasting quality of transplant boxes treated with three different preservatives and (b) whether any of the preservatives used have adverse affects on the trees planted in the boxes were continued. The preservatives used were "Celcure", (a copper-arsenic preservative) P.C.P. (pentachlorophenol) and "Blundwood" (a creosote preservative). P.C.P. appears to have an adverse effect on *P. patula* causing casualties and a yellowing of the plants. The boxes are used year after year until no longer fit. The timbers used were *Grevillea*, cypress and cedar with untreated cedar as control. Indications so far are that the preservatives have had little or no effect yet on the deterioration of the boxes which is only slight after three years.

180. *Effect of different kinds of sheltering and shading on nursery beds.* An experiment on this subject in which four different kinds of sheltering

and shading were used failed because we had continuous cloudy weather at the time of pricking out and obviously no shading at all was required.

181. *Transplant spacing experiment in beds.* An experiment was done in which the plants were pricked out at two by two, three by three, and four by four inches. Wider spacing was not used as it was wished to keep the experiment within practical district economics. There was little difference in height growth or survival percentage between the treatments but the wider the spacing, the sturdier and better developed the plant. It remains to be seen how they behave when planted out.

182. *Effect of restricting evaporation. Transplant boxes.* As a result of a Kenya pilot experiment, an experiment was done in which (a) boxes were sunk to ground level (b) boxes were normally placed on a gravel base and (c) boxes were normally placed on a gravel base but mulched with chopped straw after the short rains, i.e. for the dry season. The species used were *P. patula* and *P. radiata.* The results of this first experiment were that the sunk boxes and the mulch increased the height of *P. radiata* by 8% and 2% and of *P. patula* by 36% and 10% respectively, again demonstrating the fact that *P. patula* is much more sensitive than *P. radiata.* It should be noted, however, that sinking the boxes is much more expensive as (a) they have to be dug up frequently for pruning off the roots which have grown through the bottom of the boxes and (b) wear and tear and termite damage to the boxes is severe.

183. *Effect of formalin on the soil and plants in seed beds and transplant boxes.* This experiment was done by the mycologist, Kenya, in Muguga nursery with *P. patula.* There were four treatments in which formalin was used on (a) the seed boxes only (b) the transplant boxes only (c) on both the seed boxes and the transplant boxes with (d) an untreated control. Little effect was produced on survival percentage by any treatment, and the application of formalin on both the seed boxes and the transplant boxes only increased the height growth by less than half the increase produced by the lower level of application of N.P.K. described above. The formalin treatment was very expensive and quite outside the range of practical forest economics. The soil in the seed boxes was 50% forest soil and 50% Athi river sand, while that in the transplant boxes was Muguga standard mixture. Treatments were applied three weeks before use and consisted of soaking the soil to four inches depth with a solution of "formalin 40%" at a rate of 250 c.c. to one and a half gallons of water.

C. Short term planting out problems

184. These short term experiments were started in 1952 to compare different establishment techniques. So far 64 experiments have been completed and 11 have been started in the long rains of 1956. The results summarised below are only tentative as the experiments must be repeated for a number of years in order to cover the climatic range.

185. Planting stock from different dates of sowing in the nursery. With *P. patula* the sizes of plants put out have ranged from 2 to 14 inches. Measured after a year, the increment and vigour of the largest plants has been the best and except with the smaller plants (six inches and under) survival percentage was generally good. If we wish to use plants larger than 8 to 12 inches, we must either find improved nursery techniques, or else be prepared for the costs of a longer period in the nursery.

186. With *P. radiata*, plants put out have varied in size from three to 25 inches. Survival percentage for all sizes has been very good (over 90%). Again, within the range used, the bigger the plant, the greater the increment and vigour. This species is tough and it appears unnecessary to use plants larger than those that can be raised in the nursery in one year with our present techniques.

187. The sizes of *C. lusitanica* used have varied from three to 24 inches. Survival percentage was generally good (90 to 100%) except for the smaller sizes, and again the bigger the plant the better the increment and vigour. With this species it appears that post-long-rains sowings will produce plants sturdy enough for the purpose.

188. It should be noted that in all these experiments the plants used came from the date of sowing experiment already described on page 58 but they are described here in terms of their height rather than their age, as this is probably the more important property.

189. *Different dates of planting.* In this subject we have now three years experimental experience of weekly planting from the middle of March to the end of May each year for *P. patula*, *P. radiata* and *C. lusitanica*. It would appear that with *P. patula*, the earlier it is planted, the greater the growth and development, and it is worth while to grow extra stock and risk very early planting. The advantage of very early planting with *C. lusitanica* and *P. radiata* is much less and hardly worth

the risk. It should be noted that, with all three species, height growth and survival percentage drop markedly with late planting.

190. In these experiments at each date of planting an estimate of soil wetting is made, and from the rainfall records the rainfall "build up" allowing for evaporation on dry days is calculated. When we have at least five years results we should have a fairly complete picture of the implication of the results.

191. *Planting stock raised by different box and bed techniques.* The experiments of 1953 and 1954 were continued with *P. patula*. These experiments have compared (a) stock grown in boxes (b) stock grown in "Swaziland" beds and root pruned with piano wire and (c) stock grown in open beds without undercutting the tap root. This last stock was lifted with as much root as possible and planted naked rooted (d) as (c) but the roots cut to four inches before planting. All stock was seven to ten inches at the time of planting out. 1955 was a dry year and the only treatment that did any good (25 inches height and 91% survival) was that of the boxed plants. This is compared with the results of 1953 and 1954 experiments which indicated the possibility of using open beds with success. It appears therefore that in the vagaries of the climate of Muguga with *P. patula* the use of boxes although much more expensive, is probably a worth-while insurance against failure in adverse climatic conditions.

192. *Comparison of different sizes of planting holes.* Experiments in this subject with *P. patula* and *C. lusitanica* over three years 1953, 1954 and 1955, planting in holes six by six inches and 12 by 12 inches have shown that in all experiments with both species there has been no difference in height growth or survival percentage. Under Muguga conditions therefore, it appears unnecessary to go to the expense of the larger planting holes. It is possible that in hard compacted soils, the larger holes may be advantageous.

193. *Comparison of planting stock raised in different nursery soils.* We have now done six experiments over three years with *P. patula* and *P. radiata* comparing stock that had been raised in six different nursery soils.

(*a*) 100% pine soil.
(*b*) 50% pine soil 50% forest soil.
(*c*) 100% indigenous forest soil.

(*d*) 100% local soil (after 40 years of wattle).
(*e*) Muguga standard mixture.
(*f*) Muguga standard mixture less basic N.P.K.

194. In general, there has been little to choose between the first three soils, but all had an advantage over the local soil. In all experiments, the plants raised in the Muguga standard mixture—with or without basic N.P.K.—maintained and increased the advantage they had gained in height growth. The only amomaly was in the experiments of 1955 when *P. patula* which had been grown in 100% pine soil showed an increase of 57% in height growth, over the control treatment (d), and 35% over the Muguga standard mixture (e). This is the only case in the very many of our experiments that a pine soil has given a taller tree than the Muguga standard mixture.

195. *Comparison of different depths of planting.* Four experiments with *P. patula*, *P. radiata* and *P. leiophylla* have been done in the last two years in which the plants were planted (a) at the collar (b) two inches above the collar and (c) four inches above the collar. In no case has the deeper planting caused any deleterous effect (nor any advantage) under Muguga conditions. This practice of deep planting if proved by further repetition may be beneficial under conditions where droughts are experienced, as it tends to put the root systems down below the upper layers of the soil.

196. *Effect of fertiliser at planting time.* Four experiments have been done in the last two years with *P. patula* and *P. radiata*, in which fertilisers, both organic and inorganic have been added to the soil in the pit before planting. In all these experiments no gain in height growth or development has been achieved, but the fertilisers, whether organic or inorganic have in general slightly reduced the survival percentage. The fertilisers used were (a) control—no fertiliser (b) half ounce of our standard inorganic fertiliser added to the soil in the pit before planting and (c) 1 oz. of organic fertiliser added to the soil in the pit before planting, the mixture containing 25% dried blood, 25% hoof and horn and 50% steamed bone meal.

197. *Comparison of bare-rooted and ball planting transplants.* Four experiments have been done in 1954-55 with *P. patula* and *P. radiata.* So far there has been no appreciable difference in either mean height growth or survival percentage between the treatments.

198. *Comparison of "normal" and "overgrown" nursery stock.* Experiments were done with both *P. patula* and *P. radiata.* The *P. patula* stock compared (a) stock in one-year boxes (nine inches high) (b) stock in one-year beds (seven inches high) (c) stock in two-year boxes (16 inches high) (d) stock in two-year beds (23 inches high) (e) stock in three-year boxes (23 inches high). The *P. radiata* stock was (a) nine months ex boxes 16 inches high (b) nine months ex beds 12 inches high and (c) 20 months ex boxes 29 inches high. In general with both species the survival percentage of all treatments was high and over 90%. In height growth all treatments of both species finished the first year at about the same height (*P. patula* 28 to 30 inches and *P. radiata* 45 to 52 inches) but the initially larger plants appeared sturdier and more vigorous. It does not not therefore appear economically worth-while to grow the more expensive larger plants. This experiment of course needs much repetition.

199. *Effect of storage of naked rooted stock.* Stock of both *P. patula* and *P. radiata* was lifted and all soil shaken off the roots. It was then bundled in wet gunny and taken to the planting site, and one set was planted immediately. The second and third sets were thoroughly wetted and left for 24 and 48 hours respectively. The weather was a dry sunny break in the rains. With both species there was no difference in survival percentage and height growth after one year.

200. *Effect of exposure of naked rooted stock to the sun at planting time.* Parallel to the above experiment naked rooted stock of *P. patula*, and *P. radiata* were (a) planted at once, (b) exposed dry for three hours and (c) exposed dry for six hours. With both species there were no survivals at all even after only three hours exposure. This demonstrates the need for careful supervision of storage of plants when the planting area is some distance from the nursery.

201. *Comparison of different weeding methods.* The weeding experiment with *P. patula*, started in 1954, was measured at the end of the second year. The treatments were (a) clean weeded (b) three feet diameter spot weeded and (c) unweeded. The increase in height growth of the clean weeded plots as compared with the unweeded plots was 165% while the benefit of spot weeding (and the spots were kept clean weeded) was only 24%. This once again demonstrates the very great beneficial effect of efficient weeding of the whole planted area.

202. *Effect of shamba crops and cultivation.* The experiment, started in 1955 in conjunction with the Physics Division, to study the

effects of shamba crops and cultivation on the height growth and survival of *P. patula* was ruined by the ravages of buck and porcupine. The plot has now been fenced and completely replanted with *P. radiata.*

D. Long term problems

203. The experiment, started in 1955, to determine the effect of the season of pruning on the rate of wound occlusion of *C. lusitanica* was continued. This is part of an interterritorially replicated experiment. So far no effect of season has been observed in the Muguga experiment, and after 16 months the dry season (Feb. 1st) wound area had occluded 91% and that of the rains pruning (April 1st) had occluded 80% in 14 months. The post rains (June 1st) had occluded 74% in 12 months. The experiment is still in progress. Muguga is East of the Rift. It remains to be seen what results the parallel experiments in other parts of Kenya and in the other territories produce.

204. In a second experiment, to determine the rate and direction of occlusion, measurements are taken on four radii at right angles and this so far shows rapid occlusion from the right, left and top of wound, and only very slow occlusion from the bottom of the wound upwards.

E. Species Trials (mainly exotics)

205. Twenty three new plots were planted in the arboretum of small trial plots. 1956 was the fifth year of planting and the arboretum now consists of 138 plots. These include :—

Eucalypts . . .	43 plots	(41 species)
Pines . . .	27 plots	(26 species)
Cypresses . . .	17 plots	(15 species)
Callitris . . .	3 plots	(3 species)
Acacia . . .	6 plots	(6 species)
Others . . .	38 plots	(38 species)

206. During the year, although originally planted at eight by eight feet, a number of the eucalypt plots have had to have a 50 per cent mechanical thinning. The cypress canker (*Monochaetia unicornis*) reported last year has continued its havoc in the *Cupressus macrocarpa* plot and in the first four years 22 per cent of the trees have been killed. In the adjacent *Cupressus lusitanica* plots less than one per cent has died.

207. The *Eucalyptus* snout beetle (*Gonipterus scutellatus*) appeared in the arboretum during the year and has so far attacked *E. viminalis*, *E. punctata*, *E. tereticornis*, *E. maidenii*, *E. camuldulensis*, *E. pilularis*, *E. regnans* and *E. bridgesiana*.

208. *Comments on the 1952 plots* (*at four years old*). *Cupressus macrocarpa* is the tallest cypress (19 feet top height) while *C. benthamii* is a close second. *Pinus radiata* (19 feet) and *P. patula* (17 feet) are the tallest pines followed by *P. canariensis* and *P. halepensis* both at 14 feet. The eucalypts are discussed under short term tree cropping. *Grevillea robusta* (22 feet) and *Syncarpia laurifolia* (19 feet) have both grown rapidly but are of poor form so far.

209. *Comments on the 1953 plots* (*at three years old*). Some of the eucalypts have done very well indeed and are commented on elsewhere. *E. vimalis* and *E. punctata*, which are both timber and not fuel species, were coppiced last year at two years old as their form was very poor due to wind blow. They have coppiced well, and the shoots are ten to 12 feet high. We hope to be able to select a single straight stem on each stool. Among the pines, *P. taeda* is tallest at 14 feet with *P. leiophylla* next at 12 feet followed by *P. khasya*, *P. occidentalis* and *P. montezumae* at ten feet. *P. clausa* although nine feet high still looks unhappy and rather yellow. *P. echinata* and *P. virginiana* are very poor and *P. engelmanni* is very healthy and apparently just starting to grow out of the "grass" stage. *C. lindleyi* (14 feet) looks well and is a very even crop. *Araucaria angustifolia* (Parana pine) is very sturdy at ten feet and looks a promising crop. Of the tan bark acacias *A. decurrens* (28 feet) is of much better growth and form than *A. mollissima* (21 feet) while a number of casualties of unknown cause have occurred with *A. pycnantha* (17 feet). *Callitris rhomboidea* and *C. robusta* both look well at nine feet. *Prunus serotina* is a quick growing broad leaved species from the U.S.A. and is very healthy (16 feet). The *Ulmus*, *Fraxinus* and *Chamaecyparis thyoides* are very poor indeed.

210. *Comments on the 1954 plots* (*at two years old*). Several of the eucalypts have done exceedingly well as noted elsewhere. *Callitris calcarata* is very healthy (eight feet) *Pinus hondurensis* is doing well (seven feet) and *P. pinea* (three feet) and *P. massoniana* (five feet) are very healthy though slower in starting. *Tristanea conferta* (16 feet) and *Broussonetia papyrifera* (ten feet) are very healthy and growing rapidly. *Podocarpus gracilior* looks very well at six feet. The bamboo *Oxytenanthera abyssinica* is very healthy and the new culms average 12 feet.

211. *Comments on the 1955 plots (at one year old).* The most striking species are an undetermined eucalypt from Zanzibar (believed to be near *E. camaldulensis*) which has grown 15 feet in 12 months, and *Acacia cyanophylla* (12 feet) *Crytomeria japonica* is very healthy at four feet, while the other seven species have all apparently started quite well, it is too early to comment on them.

212. *Live hedges.* A further five species were planted in the demonstration plot of live hedges for use in farm and forest work. The new species are *Agave americana* (American aloe) *Opuntia dillenii* (a prickly pear) *Caesalpinea sepiaria* (Mauritius thorn) *Pyracantha augustifolium* (Fiery thorn) and *Juniperus procera* (the local cedar).

213. Of the original nine species which are now two years old, all have grown to the stipulated size of five feet high and four feet wide and have had to be clipped a number of times, except *Aberia caffra* (Kei apple) and *Rosa multiflora*. The Kei apple is slow to get going, but the rose after being continually browsed by buck in the first year, with a little protection has now gone ahead well. It is obvous however, that without protection against buck it cannot be successfully raised in Muguga.

IV. ENUMERATIONS AND V. REGENERATION OF HARDWOODS

214. Further work was done in the territories. E.A.A.F.R.O.'s contribution was purely advisory.

VI. SHORT TERM TREE CROPPING

215. The replicated ten-acre experiment to test the relative fuel yields of three eucalypts is now one year old. Height growth differences are very significant and the order at present is *Eucalyptus grandis* of Australian origin well ahead with *E. saligna* of Australian origin second, and the local *E. saligna* (which we know to be a hybrid) third.

216. An examination of the arboretum plots shows that we already have several eucalypts which grow (at all events in the early stages) considerably faster than the local *E. saligna*. It is very probable that we will be able to find a eucalypt which will give us bigger fuel yields in a shorter time than the gum which is at present in popular use for the purpose. For example, *E. saligna* of Australian origin at three years old is the same height and diameter but of much better form than the

local *E. saligna* at four years old. We have three gums which have reached over 25 feet in height in 24 months *E. regnans* (28 feet) *E. bridgesiana* (28 feet) and *E. grandis* (26 feet). Among the three year olds we have *E. botryoides* (30 feet) *E. macarthuri* (29 feet) and *E. muelleriana*, *E. maidenii* and *E. resinifera* (all 25 feet). Among the one year olds a gum species not yet determined which came from Zanzibar and is believed to be near *E. camaldulensis* has grown 15 feet.

217. The above figures are all those of top height i.e. the height of the best 100 trees per acre.

VII. YIELD TABLES FOR IMPORTANT SPECIES

218. Considerable progress has been made in the collection of height—age data so that the quality classes of the cypresses of the *C. lusitanica* group and of *P. radiata* and *P. patula* can be standardised on an East African basis.

VIII. MUGUGA (E.A.A.F.R.O.) ESTATE

219. Maintenance of the estate has continued. Work has included gum and wattle thinning, the clear felling of old wattle for conversion to softwoods for experimental purposes and eucalypts to provide fuel for the station. During the year Compartment Register Histories were started for all sub-compartments with a view to a later preparation of an Estate Working Plan.

FOREST ENTOMOLOGY

J. C. M. Gardner

Survey of East African Forest Insects

220. The reference collection now contains about 920 species (all with at least some biological information), some 270 having been added in the year; unfortunately one-third of the whole collection remains to be specifically identified, the species concerned either being new to science or at least not represented in the British Museum collection; these must wait until specialists can be found to study them, it is hoped in the not too distant future. Only twenty-five of our new species have so far been described, mostly by Sir Guy Marshall (Curculionidae) and Professor Karl Schedl (Scolytidae). The Survey has been selective to the extent that we have so far concentrated on insects associated with definite species

of trees, and even then the majority of our records relate to wood-boring species. Much of the work is laborious, involving the breaking-down of large logs; numerous wood (and other) samples are caged in the insectary at Muguga and emergences may occur after three years or more. This method probably explains the large proportion of new species acquired. It is of interest, to give an example, that from samples of a large consignment of mahogany logs received in Nairobi no less than nine species of borers were reared, five of them new to science; these logs incidentally had been left on the forest floor too long.

Special Problems

221. *Oemida gahani* Distant. A second interim report on this Cerambycid borer, with particular reference to attack on living cypress trees, is in preparation. The field work was under the charge of J. O. Evans (Insect Forester, Kenya) until March 1956 when he resigned; the project was then taken over by the Forest Entomologist, Kenya. *O. gahani* was originally described from Pretoria and later came into prominence in Kenya as damaging first structural Podocarpus and later living cypress and juniper; the geographical distribution seemed a little odd. However, the gaps are now being filled in and we now know it from west Uganda; there are specimens in collections at Salisbury and Bulawayo from Southern Rhodesia and Natal (teste D. J. W. Rose and E. A. Pinhey). In September-October, 1955, Evans accompanied me on a tour in Tanganyika and we found it to be abundant on the northern slopes of Mt. Kilimanjaro up to 7,000 feet; on the west and east slopes of Mt. Meru, in the natural forests of Merera (N. Highlands) and of Nou (Central Tanganyika) and in the Mufindi area (S. Highlands); the species is present but perhaps less abundant in the W. Usambaras. In all these cases, with the exception of Mt. Meru, we found no evidence of damage to plantations and only dead wood (stumps, logs, etc. of various tree species) was attacked. From the structural timber viewpoint the woodwork of the old fort at Arusha showed typical Oemida emergence holes and was presumably badly attacked and the wood structure of the Rest Camp at Ngorongoro (*Cassipourea elliotti*) is attacked. It is probable that *Oemida gahani* is widely spread at elevations above 3,000 feet, normally breeding in dead wood.

222. *Androeme plagiata* Aur. This is another Cerambycid borer, closely related to *Oemida* and with seemingly similar habits. This we have only recorded from the W. Usambaras where it seems largely to replace *Oemida*. It can attack softwoods in plantations (as well as dead wood) and its biology and economic importance require investigation.

223. *Seed and Fruit Pests.* We have so far relatively few records of damage in this connection. Recent records are of *Croton* seeds infested by a weevil (no living insects received as yet); *Juniperus procera* from which we have reared *Megastigmus somaliensis* Hussey (Hymenoptera); *Maesopsis* with a lepidopterous species, almost certainly new and *Podocarpus* with lepidopterous larvae.

224. *Icerya purchasi* Mask. A severe attack by this polyphagous species of Coccidae on *Acacia mollissima* (wattle) in the W. Usambaras was reported by the Silviculturist, Lushoto. The introduction of the Coccinellid *Rodolia cardinalis* Muls, was suggested (following the lines of a classical case of successful biological control of this insect in California) and living beetles of this predator species were provided for release in the area by the Biological Control Entomologist, Pretoria, whose co-operation is gratefully acknowledged. The end results of this experiment remain to be seen.

225. *Protection of Logs.* Experiments in spraying of newly felled logs to prevent attack by Ambrosia Beetles have been continued by the Forest Entomologist, Kenya (S. J. Curry). Similar work is being done in the S. Mengo forests of Uganda under the control of the Forest Ecologist, Uganda; in this case protection against the borers *Cerambycidae*, etc. is included. There is very considerable economic loss in this field and the subject needs study.

Acknowledgments

226. The Chief Conservators of Tanganyika and Uganda have each deputed two of their forest rangers to undertake insect surveys and this has resulted in the recording of much new information. The Forest Entomologist, Kenya, (S. J. Curry) has sent in large numbers of insects from the Kenya Highlands (especially *Platypodidae*) for identification, and an Insect Forester, Kenya, (J. O. Evans) working in the same area has also sent in much useful information. The valuable co-operation of several other forest officers in the three territories is acknowledged.

227. As usual we are indebted to the Commonwealth Institute of Entomology for identifications; we have so far sent 1,600 units (comprising many thousands of specimens). Some specimens of a series are retained for the National Collection and some returned to us.

HORTICULTURE SECTION

W. B. May

Forestry Work

228. This is described in the Silvicultural Section of this report.

Agricultural Work

229. It was thought possible that a dryland Lucerne variety might produce a deep taproot or a number of deep sinker roots if grown on deep friable soil. A trench some six feet deep and two feet wide was dug and the loose soil returned to the trench. Lucerne seed was sown on this treated area, also on normal nursery soil. After 11 months, the Lucerne in the treated area had not produced deep tap roots, the root system was similar to those plants grown on untreated soil.

230. A small experiment to test the effect of plant toxins was laid down in April, 1955. Seeds of barley, oats, lucerne and buckwheat were strip sown. After these crops had been harvested, lettuce was planted on all strips as an indicator crop. The results were not significant.

231. Plots of cabbage, tomatoes, beetroot, lettuce and peas were sprayed at weekly intervals from seedling stage to maturity with a one in 20,000 solution of Lugols Iodine and water. In all cases, treated plots producted slightly more robust plants than control plots, also the treated plots matured earlier than control plots, but results were not significant.

232. Seeds of various agricultural crops were sown for bulking purposes, and seed selection.

General

233. A successful union has been obtained using *Metasequioa glyptostroboides* as scion, and sapling *Cryptomeria japonica* as stock. There were two objects in view in trying to make this graft. There was a practical one that the cuttings of *Metasequioa* which were given us grew very slowly at Muguga, and it was hoped that grafting it on to a strong growing sapling would help it to grow better. This has been found to happen. There was also a theoretical one, for normally a cutting belonging to one genus can only be grafted on to a scion of another successfully, if the two genera are fairly closely related. The success of this graft is very surprising if the commonly accepted opinion is correct

that *Metasequioa* belongs to an extremely primitive family and *Cryptomeria* to a more recent one.

234. Seeds of *Rumex hymenosepalus* was sown on behalf of the East African Hides and Skins Department. This tannin-producing plant is now 12 months old, and is thriving under nursery conditions. Seeds of this species were distributed to the Territories for trial.

235. Seeds of some 76 species were received during the period under review for trial as new introductions.

236. In collaboration with Dr. B. Verdcourt, plants of *Pentas lanceolatus* were raised to enable genetical work to be carried out.

Tours

237. The Horticulturist toured parts of all the three territories, and gave advice to Forestry staff on nursery procedure.

SYSTEMATIC BOTANY

P. J. Greenway

238. The scientific staff was brought to full strength by the transfer of Miss D. M. Napper, Scientific Assistant, from the Agricultural Department, Kenya, on the 1st September, 1955.

239. Work for and on the Flora of Tropical East Africa continued and the families *Canellaceae*, *Caryophyllaceae* and *Connaraceae* have been published in April and May of this year, the first prepared by Dr. B. Verdcourt.

240. During his U.K. leave, in connection with his work on the *Convolvulaceae* of the Flora of Tropical East Africa Dr. B. Verdcourt took the opportunity to travel on the Continent. He spent six weeks visiting Paris, Geneva, Brussels, Tervueren, Moergestel, Leiden, Hamburg, Copenahgen, Charlottenlund, Stockholm and Uppsala for the purpose of examining type specimens in the botanical institutions of these cities. On his voyage back to Africa he also visited the Museo Civico di Storia Naturale at Genoa. All the personal contacts made by Dr. Verdcourt have been most valuable to the work of the East African Herbarium as the institutions visited have become more willing to lend us important type specimens and give help in other ways.

THE WORK OF THE EAST AFRICAN HERBARIUM

P. J. Greenway, B. Verdcourt and D. M. Napper

241. During the year over four hundred accessions of specimens totalling over 6,900 for naming, 6,000 already named in exchange and 261 loaned for study were received.

242. The more important of the unnamed collections were from :—

Kenya : Administration, Mr. J. Nottingham, 37 specimens; Agricultural Department, Messrs. A. W. Peers, J. C. Templer and others, 189 specimens; African Land Development, Mr. G. D. Patterson, 19 specimens; Coryndon Memorial Museum, Mr. J. G. Williams, 31 specimens; Criminal Investigation Department, seven specimens; E.A.A. & F.R.O., Messrs. D. J. Nicholson, C. G. Trapnell, J. G. Wilson and others, 191 specimens; E. A. Herbarium, Messrs. P. J. Greenway, B. Verdcourt, G. Williams and Miss D. M. Napper, 857 specimens including over 200 weeds collected by Dr. Verdcourt in England; E.A.T. & T.R.R.O., Mr. B. J. Duffy, 17 specimens; Forest Department, Messrs. M. C. Argyle, W. G. Dyson, D. G. B. Leakey, H. H. C. Pudden, Munsha Singh and others 88 specimens; Various private collectors including Mrs. J. Adamson, Mrs. D. H. Irwin, Dr. A. Jex-Blake, Col. R. Meinertzhagen and Miss J. Ossent and members of firms dealing in weed killers, 771 specimens; Tsetse Survey and Control, Messrs. P. E. Glover, W. P. Langridge and R. J. B. Power, 159 specimens; Veterinary Department,

Mr. D. B. Thomas and others 66 specimens and various government departments not included in the above lists, nine specimens.

Northern Rhodesia: Forest Department, Mr. D. B. Fanshawe seven specimens.

Somaliland: Desert Locust Survey, Mr. C. F. Hemming, 122 specimens.

South Africa: Dr. J. F. Beard, Pietermaritzburg, five specimens; National Herbarium, Pretoria, 144 specimens.

Tanganyika: Agricultural Department, Messrs. H. J. de S. Disney, G. K. Reakes Williams and others, 65 specimens; Colonial Insecticides Research, Dr. G. W. Ivens, 310 specimens; Colonial Office Botanists at Songea, 22 living plants for transmission; E.A.A. & F.R.O., Messrs. D. J. Nicholson and C. G. Trapnell, 24 specimens; E.A. Herbarium, Messrs. P. J. Greenway, B. Verdcourt, and G. Williams, 45 specimens; E.A. Malaria Research Unit, Mr. G. Webbe, 15 specimens; E.A. Medical Survey and Filariasis Research Unit, Dr. H. Trant, 32 specimens; Forest Department, Messrs. W. Carmichael, J. F. Hughes, C. D. Mgaza, M. S. Parry, P. C. Richmond, S. Semsei, F. G. Smith, G. Watkins, R. C. Willan and others, 1,428 specimens; Government Chemist, 35 specimens; Sisal Research Station, Dr. F. Leutenegger, 18 specimens; Tanganyika Agricultural Corporation, Mr. B. Anderson, 69 specimens; and various private collectors, especially Mr. S. J. K. Collins, 113 from Kilimanjaro; Dr. R. Hofsommer, 79 from Arusha District and Mrs. H. Stonely 26 from Mafia Island; 230 specimens.

Uganda: Agricultural Department, Messrs, I. Langdale-Brown and J. G. Wilson, 361 specimens; Animal Health Research Centre, Mr. K. W. Harker, 141 specimens; C.M.S. Hospital, Mengo, Dr. R. Y. Stones, 105 specimens; E.A.A. & F.R.O., Messrs. W. Wilkinson, J. G. Wilson and others 161 specimens; E.A. Fisheries Research, three specimens; E.A. Herbarium, Dr. P. J. Greenway, 20 aquatics; Forest Department, Messrs. I Dale, H. C. Dawkins and others 224 specimens; Makerere College, Mr. P. Huxley (Kilimanjaro) and Dr. E. M. Lind 212 specimens.

From England: we have received from the Imperial Forestry Institute 29 Convolvulaceae and from the Royal Botanic Gardens, Kew, 54 specimens of the same family to name because Dr. B. Verdcourt is working on this family for the Flora of Tropical East Africa.

243. The named specimens were received in exchange and for help given and were from :—

Belgian Congo, I.N.E.A.C., Yangambi, 42 specimens; *Belgium*, The Jardin Botanique de L'Etat, Brussels, 183 specimens; *Denmark*, Botanical Museum and Herbarium, Copenhagen, two photos of Forskol types; *England*, The Royal Botanic Gardens, Kew, 3,700 specimens including 239 photographs of types; *India*, Delhi University, 80 specimens through the Forest Department, Kenya; *Israel*, The Hebrew University, Jerusalem, 103 specimens; *South Africa*, Dr. G. W. Reynolds, 20 Tropical African Aloes most of them type specimens and 28 Aloe photographs; National Herbarium, Pretoria, 532 specimens; *Sweden*, Institute of Systematic Botany, University of Uppsala, Uppsala, 475 mosses collected by Dr. Dr. O. Hedberg on the East African mountains and containing type specimens; *Uganda*, Makerere College, 16 marine algae collected by Dr. E. M. Lind on the Kenya coast.

244. The specimens from Kew are particularly valuable as most of them were collected by Messrs. J. B. Gillett and R. B. Drummond and J. H. Hemsley, Colonial Office Botanists during their recent botanical expeditions to East Africa. Dr. O. Hedberg's named mosses from the

Ruwenzories, Mts. Elgon, Kenya and Kilimanjaro have added greatly to the moss collection in the Herbarium and Dr. G. W. Reynolds *Aloe* specimens will be of great value as he is now making a special study of the Tropical African Aloes and they are described or mentioned in the series of papers he is publishing on the result of his work.

245. Over three thousand five hundred named duplicate specimens were distributed to various botanical institu ions of which over two thousand seven hundred went to the Royal Botanic Gardens, Kew; and the bulk of the remainder to the National Herbarium, Pretoria; the British Museum (Nat. Hist.); Imperial Forestry Institute, Oxford; Missouri Botanical Gardens; New York Botanical Garden and the Grey Herbarium, Harvard University, Cambridge, Massachusetts.

246. Loans of specimens to botanical institutions amounted to over 8,000 specimens. These loans were to :—

Austria, Natural-historisches Museum, Vienna, five Lobelias; *Belgium*, Jardin Botanique de L'Etat. Brussels, 12 *Ocotea* spp; *Brazil*, University of Recife, Pernambuco, 86 Fungi; *Holland*, Rijksherbarium, Leiden, 12 *Canarium* spp; *Indonesia*, Herbarium Bogoriense, Bogor, Java, 129 Lauraceas; *Portugal*, Botanical Institute of the University of Coimbra, 39 *Dissotis* etc.; *South Africa*, National Herbarium, Pretoria, 12 miscellaneous; University of Stellenbosch, Stellenbosch, five Mesembryanthemums and 20 *Romulea* spp. and Witwatersrand University, Johannesburg over 100 index cards of native medicinal plants with their uses; *Sweden:* Institute of Systematic Botany, University of Lund, Lund, nine *Aristea* spp. and Institute of Systematic Botany, University of Uppsala, Uppsala, 17 *Romulea* spp., nine types and 31 high-altitude plants from East African mountains; *United Kingdom*, British Museum (Nat. Hist.), London, 94 *Phillipia* spp. for the Flora of Tropical East Africa, 42 ferns etc. and 40 Arabian Leguminosae; Imperial Forestry Institute, Oxford, 287 *Terminalia* spp; Royal Botanic Garden, Edinburgh, 124 Gesneriaceae for the Flora of Tropical East Africa and 16 *Heliotropium* spp.; Royal Botanic Gardens, Kew, over 6,800 the most important being the families Capparidaceae, Cucurbitaceae, Bambuseae of the Gramineae, Hippocrateaceae, part of the Mimosaceae and Papilionaceae, Nyctaginaceae, Polygonaceae, Orobanchaceae, Sapotaceae and Resedaceae, with further ferns for the Flora of Tropical East Africa; *United States:* Missouri Botanical Garden, St. Louis, 21 Lichens and 20 *Valeriana* spp.; U.S. National Herbarium, Smithsonian Institution, Washington, 22 *Desmodium* spp. and Yale University, School of Forestry, New Haven, three Centrolobiums, one time in cultivation in Tanganyika.

247. For study in connection with the Convolvulaceae of the Flora of Tropical East Africa by Dr. B. Verdcourt we were loaned types and other specimens by the British Museum (Nat. Hist.), London; Botanical Institute, University of Florence, Italy, 11 specimens; National Herbarium Pretoria, South Africa, 96 specimens; Institute of Systematic Botany, University of Uppsala, Uppsala, Sweden; The Botanical Garden and Museum, University of Zurich, Zurich, Switzerland and The Royal Botanic Gardens, Kew, England, 29 specimens, and our thanks are due to the directors of these institutions.

248. Local loans have been from Mrs. J. Adamson, Isiolo, Kenya, 39 flower paintings for naming; Mr. H. D. van Someren, Mweiga, Kenya, 69 ferns to loan to the Royal Botanic Gardens, Kew; The Scott Agricultural Laboratories, Nairobi, Kenya, six grasses for study; The Forest Department, Kitwe, Northern Rhodesia, eight Rubiaceae for naming and the Forest Department, Morogoro, Tanganyika, four *Tetrorchidium* for study.

249. Requests for plant material both living and dead from all parts of the world continue and the following have been collected and sent :— to *Germany*, six Zannichelliaceae; *Israel* 200 pounds of *Catha edulis*, through the help of the Forest Department, Kenya; *Kenya*, E.A.A. & F.R.O., seeds of *Pentas* and Convolvulaceae. E.A. Hides, Tanning & Allied Industries Bureau, seeds of *Rumex hymenosepalus* through the Foreign Plant Exchange, Plant Introduction Section, U.S. Department of Agriculture; *South Africa*, National Herbarium, Pretoria, 18 living plants and seeds of succulents collected in Tanganyika and Kenya; *United Kingdom*, British Museum (Nat. Hist.) London, fossil casts of trees from the Kenya Rift; Cambridge Botanic Gardens, seeds of *Cyrtanthus* and four rare succulent plants collected in Tanganyika and Kenya; Colonial Products Council, London, 100 pounds of fruits of *Afromomum amaniensis* and *A. mala*, samples of stems of *Abutilon longicuspe* and *A. mauritianum*, roots of *Thylachium africanum* and *T. thomasii* for various investigations; Royal Botanic Gardens, Kew, seeds of *Abrus*, *Anticharis*, *Carvalhoa*, *Cyrtanthus*, *Rauvolfia* spp., a new *Sesamum* and rare succulents from Kenya and Tanganyika, corms of *Amorphophallus* and also 25 living plants of rare succulents collected in Kenya and Tanganyika; Nottingham University, roots of *Rauvolfia mombasiana* for chemical and anatomical investigations; *U.S.A.* seeds of *Delphinium leroyi* and *D. macrocentron* and 200 pounds of root bark of *Rauvolfia mombasiana* for chemical investigations.

250. Over eight thousand five hundred specimens were named for government departments and correspondents in East Africa and for institutions and others in South Africa, the United Kingdom and the United States of America.

251. The following new species were described from the Herbarium :- *Adinandra schliebenii* Melch var. *glabra* Verdcourt (Theaceae) in *Kew Bull.* 1954, 4, p. 608. *Procter 183!* holotype.

Chytranthus sacleuxii Pierre & Sacleux subsp. *longiflorus* Verdcourt (Sapindaceae) in *Kew Bull.* 1954, 4 p. 604. *Drummond* and *Hemsely 1937!* isotype.

Grevea eggelingii Milne-Redhead (Montiniaceae) in *Hook. Ic. Pl.* tt. 3541-3544 (1955). *Eggeling 6438!* isotype.

Memecylon melindense A. & R. Fernandes (Melastomataceae) in *Bull. Soc. Brot.* 29: 63 (1955). *Dale 3885!* isotype.

Uvariodendron anisatum Verdcourt (Annonaceae) in *Kew Bull.* 1954, 4, p. 596 (1955). *Verdcourt 526!* holotype.

252. Amongst a very fine collection of East African mosses presented to the East African Herbarium by Dr. O. Hedberg, Institute of Systematic Botany, University of Uppsala, Uppsala, Sweden, we received 12 type specimens, these with the five newly described together with 35 found in the course of the year brings the total number of known types in the Herbarium up to 816. Amonst those found were four described in W. C. H. Peters "Reise Nach Mossambique Botanik" published as far back as 1862.

253. Owing to the long delays from London of supplies of paper for mounting specimens this work has been considerably retarded and as a result the total number of specimens filed into the Herbarium amounted to only 5,901 sheets. In addition 3,046 sheets comprising 47 families were transferred from the Coryndon Museum. Four hundred and one sheets were added to the grass collection bringing it up to a total of 10,627 sheets. There is now a grand total of 104,838 specimens in the Herbarium for study.

254. Work on the amalgamation of the Coryndon Memorial Museum Herbarium is completed as far as specimens have been made available by the Coryndon Museum Botanist.

FIELD WORK

255. The collection of botanical specimens, mostly locally, has continued outside office hours, more especially over weekends, when such places as Magadi, Kitui, Narok, Thika and Ngong were visited. Miss D. M. Napper during a leave period at Kikambala and Jadini on the coast collected about 50 marine algae. Mr. G. Williams during his leave in Tanganyika collected botanical specimens and seeds of *Rauvolfia* and *Carvalhoa* as well as root material of the former for chemical and anatomical investigations. A leave period was also spent by Dr. P. J. Greenway on Lamu Island to which he went by way of Garissa and Ijara collecting *en route*. At Lamu throught the kindness of the Forest

Department, Kenya, Dr. Greenway was able to visit the adjacent islands and see something of the northern coastal vegetation of Kenya. He then continued his journey by road via Malindi, Mombasa and Tanga returning via Lushoto, Moshi to Nairobi. During the trip 134 specimens in quadruplicate were collected including 35 gatherings of marine algae. The latter, together with those collected by Miss Napper, have added to the collection of this group of plants which are very poorly represented in the E.A. Herbarium. A search for two Aloes in the Korogwe and Lushoto Districts was not successful but a collection of over 20 little known succulent plants, some wanted by the Royal Botanic Gardens, Kew, made this part of the journey profitable. The botanical specimens and plants including the seeds collected on this journey have been distributed to Kew, Pretoria, Cambridge and the New York Botanical Gardens and a full set of the dried plants has been retained for the East African Herbarium.

THE DEVELOPMENT OF ANIMAL INDUSTRY RESEARCH

SURVEY OF PROGRESS

M. H. French

256. The Animal Industry Division which is jointly the responsibility of E.A.A.F.R.O. and E.A.V.R.O., was deliberately so established in order that it could concentrate on problems lying within that indefinite borderland of interests common to both parent Organisations. A review of past policies in the Colonial Empire shows how vicariously poised this sphere of activities has been, where sometimes its attachment has been to Agricultural and at other times to Veterinary Departments. Such attachments have inevitably biased research towards the interests of the acting parent organisation, but the economic importance of mixed farming is so forcing attention, with increasing urgency, on to this common field of activities that this East African experiment of dual control was established. Last year's report emphasised the delays to the development of this new approach due to limited financial resources, and was written in the hope that it represented the end of the difficult developmental period. This attitude was too optimistic, and finance has again been the most difficult problem facing the Division and retarding its progress. This does not mean that the Division has been purposely starved by its parents, because both have in fact contributed more than their pre-arranged share of finance, but the future of this economically important phase of research depends on its ability rapidly to develop to the stage where its workers are not hampered by lack of facilities and materials. Fortunately, the additional funds of both parent organisations have allowed the essential but sub-optimal maintenance of cleared land, but the needs for fencing and watering facilities and the establishment of productive pastures have still to be achieved.

257. Last year's report referred to the attempts to establish methods of assessing the relative values of pastures by the use of suitably conditioned cattle, but these were borrowed and had to be returned before the experiments could begin. Now, with a grant from the Amani Reserve a foundation herd of carefully selected cattle from the Northern Frontier District of Kenya has been established for beef studies. These animals will be used to produce future herds of known history, age and management which can be used in the experimental programme. The plane of nutrition, and hence of development, has received careful thought in order that it should bear some relation to practical conditions, which vary

from the subsistence conditions in many African areas to the highly productive rationing capable of achievement on certain European farms. The policy is therefore to permit maximum growth during the rainy seasons and then if possible to maintain weight, but not necessarily condition, during the dry seasons.

258. The Large White pig unit has been expanded and a new feeding shed is nearing completion in which it will be possible to feed all pigs individually, and to record their food consumptions from weaning to slaughter. The unit has been developed from progeny purchased from the Tanganyika Veterinary Department herd, and the aim is to avoid bringing in fresh blood so that the uniformity of the individual pigs for food conversion studies can be predicted.

259. Both the sheep and poultry units have remained on a care and maintenance basis, nor has it yet been possible to study the incubation problems that await investigation.

260. Reference was made last year to Dr. Rogerson's attempt to adapt the classical digestibility procedures so as to make them more capable of measuring the feeding values of rapidly growing herbage. These studies have been put into practice, and three grasses have been studied at different stages of maturity. In his report last year, Dr. Rogerson referred to the inadequacy of the classical 'by difference' procedure for evaluating the nutritive value of cassava. He has made comparable studies with a protein concentrate this year, and has again shown that the accepted standard procedure gives different estimates of nutritive value as the proportion of concentrate to basal ration is altered. Quite apart from the difficulties introduced into the practical application of reported feeding values, such work emphasises the need for a revision of established procedures if the results are to be of value in scientific investigations. It is hoped that he may be able to establish a respirometry section in order to continue with these important problems.

261. Dr. Rogerson has also been investigating the use of lignin as a tracer in digestibility studies, and has embarked on a programme for ascertaining the site and the degree of digestion of food during its passage through the different sections of the ruminant alimentary canal.

262. These nutritional studies are being supplemented by other biochemical investigations into the composition and quality of the crude protein and carbohydrate fractions of feedingstuffs. As described

elsewhere by Mr. Glover and Dr. Duthie, an important contribution has been made to the interpretation of the digestible crude protein contents of both single and mixed feeds, so that it is now possible to predict, with reasonable accuracy, the digestible fraction from a knowledge of the total crude protein content of a ration. The latter can easily be determined, but a determination of digestibility is so time-consuming and costly that there is little hope of sufficient trials ever being conducted to collect a full knowledge of the nutritive values at all stages of maturity of the enormous variety of grasses, edible shrubs, and tree leaves consumed by ruminants in the tropical zones. The new equation makes this task a relatively simple matter and will provide results which are sufficiently accurate for all practical rationing purposes in both the temperate and the tropical regions of the world. Like the work of Dr. Rogerson, mentioned above, the derivation of this regression equation emphasises that the classical 'by difference' technique for measuring the digestibility of foodstuffs added to basal rations is subject to considerable error, and again underlines the necessity for considering the composition of the total ration, rather than that of its individual components, when assessing its nutritive value.

263. The elucidation of regression equations of comparable accuracy for the energy fraction of foodstuffs is not so promising because of the lack of analytical precision in the assessment of the various carbohydrate fractions. Dr. Quarterman has commenced studies into the less understood fractions of the carbohydrate and fibrous components of fodders which will be continued during the coming year. The recent arrival of Mr. Phillips, a Veterinary physiologist, will enable a start to be made with a study of the movements of fibrous foodstuffs through the alimentary canal—work which is clearly related to the nutritional and biochemical aspects referred to above, but which may also have an important bearing on attempts to determine the nutritive value of herbages grazed by animals in the field.

264. Mr. Lampkin has been engaged in recording the development of the offspring from the beef Zebu herd. These offspring are to be used for assessing the importance of breeding in programmes of livestock improvement, and because of this he has devoted considerable attention to the management problems associated with the large number of bulls which will be needed for the future experimental programme. He has also commenced an examination of the grazing reactions of Grade European and of Zebu stock, which will be extended to cover the climatic range from the tropical coastal belt to the higher altitude regions.

During the year he has undertaken an examination of the records of the E.A. Milk Recording Scheme, and has made recommendations for bringing this scheme more into line with those of other countries.

MINIMUM SIZE OF EXPERIMENTAL PLOTS FOR THE ASSESSMENT OF PASTURE YIELD

M. H. French

265. Reference was made in last year's report to the enormous problem posed, by the Interterritorial Research Co-ordinating Committee, of investigating the yield of natural grasslands. During this last year, over 7,700 plots at Muguga have been cut, weighed, chaffed, sampled and had their dry matter contents determined. This series of observations is a continuation of the work of previous years, so that the productive capacity of certain fodders has been assessed at different times of the year over two and, in some cases, over three years. Rainfall varies enormously in this area both in yearly totals and in seasonal distribution. Such conditions are not peculiar to Muguga but are characteristic of a wide area in the arid and semi-arid zones of East Africa, and the unexpected results must therefore have a wide range of application.

266. The most striking feature of these results is the prediction therefrom that the minimum plot sizes to give a ten per cent coefficient of variation in dry matter herbage yields varies enormously according to the luxuriance of growth. Since the latter is conditioned by rainfall and soil moisture reserves, variation between seasons for the same herbage species on the same plots is to be expected, but the estimated range for the size of plot to achieve a ten per cent coefficient of variation, of from 16 to 755 sq. yd., for the same grass is surprising. That the minimum plot size necessary to achieve the prescribed coefficient of variation should vary between species was expected but the magnitude of the minimum plot size at certain seasons of the year was not. Because of the seasonal aridity of the soils over a large part of East Africa, and the unpredictability of rainfall in any particular period of the year, the implication of the results is that minimum plot sizes must be many times greater than would be considered adequate in temperate areas and, on the basis of the results obtained, the minimum size to cope with the varied local seasonal herbage growths must be placed at 600 sq. yd.

267. In view of this it is not surprising that other attempts at Muguga to measure herbage productivity, by plots of sizes varying between 9.33

sq. ft. and 135 sq. ft., have failed to give estimates with a ten per cent coefficient of variation, and plots of 637 sq. ft. have not done so reliably. This has led to a serious complication of the efforts to measure herbage consumption by grazing cattle. Admittedly such grazing studies as have been conducted (eight series in all) have been complicated by variations in the accuracy of liveweight determinations of the grazing oxen, but the discrepancies in estimated daily herbage consumptions (from four lb. to 27 lb. dry matter per day by 5½ cwt. cattle) emphasise the inaccuracy of this method when the replicated sampling plots are seriously deficient in size.

THE APPARENT DIGESTIBILITY OF CRUDE PROTEIN BY THE RUMINANT

J. Glover, D. W. Duthie and M. H. French

268. An examination was made of the results of East African studies on the apparent digestibility of crude protein by cattle and sheep. The purpose of this work was an attempt to detect possible differences in the apparent digestibility of crude protein which might be ascribed to differences in either type of animal, climate, or composition of feed. No such differences could be detected, but it was found that the total percentage content of crude protein in the feed was the most important factor in determining its digestibility.

269. The conclusion was tested by examining world data. A general equation $Y = 70 \log X - 15$, where X is the crude protein content of the feed, and Y the digestibility coefficient of the protein, proved to be of general application, irrespective of the composition of the feed, the breed or type of cattle, sheep or goats, or the climate in which the results were obtained. Thus for the first time a link has been provided between the large bulk of data from temperate regions and those hitherto neglected and apparently aberrant data from the tropics and sub-tropics, particularly those appertaining to low protein fodders. In doing this a uniform world pattern of apparent digestibility of protein by the ruminant has been established.

270. The curvilinear nature of the relationship adequately explains a large part of the variability of the results obtained by classical "by-difference" methods and those of "associative effect" trials. In these the underlying assumption has been that there is a linearity in the

relationship between the percentage of crude protein in the feed and its digestibility, and that the effects are simply additive. This assumption, which is not supported by the work mentioned above, leads to erratic results, the nature of which can be predicted by the new equation.

271. The general equation has considerable practical value. Irrespective of whether herbages or mixed feeds are concerned, a chemical determination of the crude protein content of the material and the employment of the equation will provide a useful estimate of the average apparent digestibility of the crude protein of the feed without the necessity to conduct trials with animals. It can therefore be used for the determination of the average digestibility of crude protein in rapidly growing grasses and herbages at different stages of development; for the evaluation of average crude protein digestibility of single or compound feeds in those parts of the world where adequate facilities for digestibility studies are not available; and in computing maintenance and production rations for meat and milk.

272. Although this equation was derived from a study of normal feedingstuffs, we have also shown that it applies to the digestibility of simple nitrogen supplements such as urea and ammonium compounds, which further strengthens the argument that it is the level of nitrogen (crude protein) in the normal whole feed which determines its digestibility, substantially irrespective of its composition.

273. Three papers on this subject have been accepted for publication in the Journal of Agricultural Science.

AN ATTEMPTED CHEMICAL METHOD FOR DETERMINING THE DIGESTIBILITY OF CRUDE PROTEIN

D. W. Duthie

274. A programme of work was planned to find an analytical chemical method for determining the digestible protein in feeds, so as to avoid the necessity of animal digestibility trials. The protein fraction of herbages was studied first, using samples of the actual foodstuffs which had been fed by Dr. Rogerson in digestibility trials with sheep, so that the animal trial result for each individual sample was known. Hydrolysis with sulphuric and hydrochloric acids of different strengths, with and without catalysts of many kinds, were tried over a wide range of boiling

times, and the amino acids in the hydrolysates were determined by the method of Pope and Stevens (*Biochem. J.*, 33, 1070). Analytical difficulties were encountered because the hydrolysates were coloured and the amino acid content was low, but these were overcome by modifications which made the method much more sensitive. Even then there were discrepancies, but these seemed to follow a fairly regular pattern, and it was decided to investigate the method as applied to plant materials.

275. The final stage of the Pope and Stevens method for determining amino-N is a determination of copper, and they found that the molecular relationship copper/amino nitrogen of 0.44 held for most amino acids, but this had already been questioned by Woiwod (*Nature*, 161, 169) and there appeared to be some doubt as to its validity. In collaboration with Mr. M. T. Friend, a sensitive method for determining copper was applied to the Pope and Stevens method, using *bis*-cyclohexanone oxalyldihydrazone as a colorimetric reagent, and 17 amino acid solutions were tested, both singly and in mixtures. A wide range of factors was found for the individual amino acids, but when mixtures were used the range narrowed as the complexity of the mixture increased, until mixtures of 9, 11 and 17 amino acid solutions gave a factor range of 0.48 to 0.49 with an average of 0.483. Variations in technique produced different factors, and it was clear that the method must be standardised, but with our method 0.48 seemed to provide a suitable average factor. When factors for herbage and supplementary animal feedingstuffs were calculated by the method of weighted means from partial amino acid compositions given in the literature, an average factor of 0.48 was again obtained, showing this to be suitable for the work on protein digestibility and this new factor will be applied to past and future hydrolysis studies.

CARBOHYDRATE STUDIES ON HERBAGE

J. Quarterman

276. The cellulose, xylan and lignin components of East African herbages form more than half the dry weight of all but the youngest grasses. The attention of this section has for this reason been focused mainly on the fibrous fraction of the plant carbohydrates. The early work was devoted to an analysis of several fodder species for the principal organic constituents, observing their changes during herbage development through two rainy periods and the intervening dry seasons. Against the background of the information collected it has been possible to plan future work, and the emphasis is now concerned with the adaption of

recent knowledge of lignin chemistry to a more accurate estimation of this material than is possible by existing conventional methods. It is also planned to investigate the ruminal digestion of the fibrous constituents by *in vitro* techniques.

277. During the past year, seven grassland species (*Eragrostis tenuifolia*, *Chloris gayana*, *Pennisetum purpureum*, *Digitaria scalarum*, *Cynodon dactylon*, *Pennisetum clandestinum* and *Indigophora* sp.) were analysed at regular intervals for cellulose, xylan, lignin, pentosans, nitrogen, ash and, in some cases, crude fibre and true protein. Sampling was designed so that the material cut for consecutive analyses was taken from a section of the herbages which had not been cut since the beginning of the experiment. In this way every sample had grown continuously from the same date to the time of cutting. The work is not yet complete but has gone far enough to allow some conclusions to be drawn, of which the following is a brief summary.

278. The gramineaceous species all have a cellulosan (cellulose plus xylan) content of about 45% after the ninth week of growth and this does not then vary during the rest of the year. The xylan component usually represents 10% to 20% of this fraction. The lignin values, which fluctuate during the first nine weeks growth from 6% to 10% of the dry weight, rise gradually and evenly to 18% at the end of the year. During the whole year *Eragrostis* sp. has, exceptionally, only half this value and for the first six months *Indigophora* has a lignin content 50% higher than the other species. The ratio of lignin to lignin plus cellulosan is apparently constant for some species while the crude fibre is, within small variations, about 55% of the sum of lignin and cellulosan. Comparable data have not been obtained in the temperate areas for periods of growth longer than sixteen weeks but, during this period, the values reported are similar to those recorded at Muguga. In East Africa, grass is commonly allowed to grow into the dry season, and to mature *in situ*. Under such conditions it becomes considerably more lignified, and the other constituents do not then increase appreciably.

279. The crude protein content of young grasses in the temperate zones usually averages about 20% to 30% of the dry matter and then decreases to a much lower level when three months of age. At Muguga the initial protein values are comparable but subsequently some species behave like temperate grasses (e.g. *Digitaria* and *Cynodon*) while others maintain a higher crude protein content (e.g. *Eragrostis*, *Indigophora* and *Pennisetum purpureum*). While the proportion of true protein in

the crude protein fraction varies between species, it does not change appreciably through the year for any species.

280. Conventional methods of lignin analyses, using strong mineral acids, are susceptible to error, and the possible use of the alkaline nitrobenzene oxidation of lignin is being investigated as a method for its more accurate estimation, particularly in digestibility trials. The first stage of the investigation, the identification of the aldehydes produced during oxidation, has been conducted with some local grasses and legumes, and the occurrence of vanillin, syringaldehyde and p-hydroxybenzaldehyde have been demonstrated.

281. Cellulose preparations from grasses of various ages show, under the microscope, different degrees of compactness which suggests a difference in their susceptibility to enzyme attack. The gradual increase in the degree of solidity and packing, with age, may be related to their rate of digestion. *In vitro* techniques are therefore being developed to examine the effect of cellulose structure and lignification, independently and together, on the digestion of cellulose by ruminal organisms.

282. An examination of the sucrose content of the fodder beets, Hunsballe, Pajberg Rex, Barres Stryn, and of two sugar beet varieties, was carried out on the Muguga crop last year. The results were normal (by European standards) except for the sugar beet which had a lower sugar content (14.6%).

PRINCIPAL RESULTS OF THE DIGESTIBILITY TRIALS USING SHEEP

A. Rogerson

The Determination of the digestibility of rapidly growing grass.

283. In last year's report it was stated that the digestibility work carried out in that period had enabled a technique to be developed which was to be used the following season in an attempt to determine the nutritive value of rapidly growing fresh grass. This modification of the classical procedure was essential in order to cope with the greater rates of growth of local than temperate grasses and their more rapid accumulation of crude fibre. The technique involved the use of more sheep for a shorter period of time and has now been found entirely satisfactory.

284. In the long rains period last year, nine digestibility trials were conducted on three different grasses, each trial involving the simultaneous use of six sheep. The grasses studied were *Pennisetum clandestinum* (Kikuyu), *Chloris gayana* (Rhodes), and *Cyndon plectostachyum* (Star). Kikuyu grass was studied at three stages of growth. The first cut was taken when growth was approximately four to six inches, the second when the herbage was eight to ten inches high, and the final cut when it was about 12 inches. Rhodes grass was studied at four successive stages of maturity, i.e. when four to six inches, 18 to 24 inches, 24 to 28 inches and about 24 to 30 inches high. The difference in sward length between the first and second Rhodes grass cuts was very marked. With the limited facilities available, this could not be avoided and the results emphasise the rapidity of growth at certain periods of the year and the consequent effects on nutritive values.

285. One result of this experiment was to show that even though the grasses were growing rapidly and presumably altering their structural and chemical constitution, yet in no instance did the calculated starch equivalent values decline by more than two units, on a dry matter basis, or the digestible crude protein by more than 0.5% during the period of the five or six days needed for a digestibility trial. The Division has no facilities for storing the large quantity of herbage needed for a digestibility trial in deep-freeze chambers, such as are used on certain stations in Europe, and it would seem that errors of the above order will have to be accepted in local nutritive value determinations on quickly-growing material. It might, in fact, be suggested that a 'spread' nutritive value such as that determined locally is of more practical significance than a value determined at one specific stage of growth, provided the 'spread' is of limited duration.

286. A brief summary of the Kikuyu grass and Rhodes grass results is given in Table I.

TABLE I

NUTRITIVE VALUE OF GREEN HERABGES
(Dry Matter basis)

Kikuyu Grass

	1st Cut	2nd Cut	3rd Cut
Approximate height	4″-6″	8″-10″	12″
Starch equivalent	55	57	49
Digestible crude protein	11.6%	7.9%	7.0%
Crude fibre	23%	26%	29%

Rhodes Grass

	1st Cut	2nd Cut	3rd Cut	4th Cut
Approximate height	4″-6″	18″-24″	24-″28″	24″-30″
Starch equivalent	55	51	42	39
Digestible crude protein	12.6%	9.7%	8.4%	7.5%
Crude fibre	27%	34%	35%	35%

287. The Rhodes grass matured more quickly than the Kikuyu grass, and was at the flowering stage when the second cut was taken—only four weeks after the plot had been cut back for the first trial; whereas the Kikuyu grass, even at the final defoliation, still showed no flowering heads. The crude fibre content of the Rhodes grass was consistently higher throughout the series of cuts, no doubt due to its stemmy nature. In spite of its fibrous state, however, the Rhodes grass compares quite favourably with Kikuyu grass on digestible crude protein contents, but is markedly inferior as a source of starch equivalent at a comparable age.

Digestibility of Crude protein in mixed rations

288. Feeding trials to measure the digestibility of the crude protein in mixed feeds have been made with the object of providing additional data for testing the validity of the equation connecting digestibility of the crude protein in a ration with the logarithm of its content. For this purpose varying mixtures of meadow hay and decorticated groundnut cake, containing up to 29% crude protein, were used.

Apparent digestibility of crude fibre in mixed rations

289. An equally interesting outcome of this series of trials was the opportunity it provided to continue the study of the interaction of a readily digestible concentrate on a fibrous basal diet, a subject which was referred to in last year's report. The basic premise of accepted systems of assessment has been the assumed additive nature of starch equivalent values of the combined feedings stuffs. This implies that, irrespective of the proportions in which two feeds may be mixed together, the starch value of the mixed diet can be calculated from the ratio of the component feeds. Doubts have been thrown on this assumption in the past, and therefore the results obtained here are in no sense original. Nevertheless they are so striking that some mention seems necessary and they are given in Table II.

TABLE II

DIGESTIBILITY COEFFICIENTS (MEAN OF 6 SHEEP) OF GROUNDNUT CAKE DRY MATTER

Ration*	A	B	C
Crude protein	96.2%	94.2%	90.6%
Ether extractives	96.9%	95.1%	87.8%
Crude fibre	74.2%	51.1%	Negative
Nitrogen-free Extractives	109.7%	100.3%	76.1%

*Ration A: 650 g. Meadow Hay +150 g. Groundnut Cake
„ B: 500 g. „ „ +300 g. „ „
„ C: 500 g. „ „ +500 g. „ „

290. Thus, by using the classical 'by difference' procedure, a different starch equivalent value for the groundnut cake can be calculated from each of the three trials, according to the proportions in which the hay and cake are fed. The respective values are 103, 100 and 84 for the particular rations 'A', 'B' and 'C'.

291. To suggest, therefore, that the starch equivalent of a feed, when determined 'by difference' calculations, can be adequately represented by a single figure, is clearly a fallacy. By varying the proportion of hay to cake, by increasing and reducing the bulk of the daily rations, by using hays of differing chemical and physical compositions, one could modify the digestibility coefficients of the groundnut cake at will, and it would seem quite possible to calculate its feeding value as varying anywhere from a starch equivalent value of around 70 to almost 110. This point is made not so much with the object of demonstrating the futility of the starch equivalent system as a practical feeding method (such rationing is by its very nature approximate), but rather as a warning that for the accurate measurements of productive potentials—such as are needed in research work—a far more sensitive measurement of net energy is needed.

Use of Lignin as a tracer for digestibility studies.

292. Although, as has been stated earlier in this report, the nutritive value of various grasses has been determined on cut material, it would be of considerable interest to be able to obtain digestibility data from grazing animals. Various indigestible 'tracers' have been used by numerous

workers from time to time with varying degrees of success. In an attempt to use the lignin fraction as such as 'tracer', unsatisfactory recoveries had been encountered in previous work in this laboratory when using the lignin estimation methods of Norman and Ellis. The more recent method suggested by Armitage has, however, been tried out on local hays with notable success. At the present time further trials are being carried out to assess the usefulness of the method for freshly cut high-protein herbage. On the results of these trials depends whether or not field digestion trials and the interesting subject of pasture productivity, as measured by animals, can be undertaken.

293. There has also been occasion to use the Armitage lignin method to study the sites of digestion of the various proximate principles of a medium quality local hay—the lignin of course being used as the indigestible plant tracer. It might be of interest to record that the particular sheep examined had been on a digestibility trial on this hay for a period of three weeks, and that during this period 1,003 g. of lignin had been ingested while 998 g. were voided in the faeces. The various 'partial digestibility coefficients' make a most interesting study and will form part of a paper to be published on this subject. It will be appreciated of course that such coefficients, particularly in the organs of the upper alimentary tract, do not merely represent true 'digestion'. They are complicated by the preferential passage of fine material and retention of coarse particles for further decomposition. The coarser particles are generally of a stemmy nature, and consequently have a higher than average lignin content. The percentage lignin, expressed on a dry matter basis, found in the contents of the various alimentary tract samples demonstrates the combined effect of digestion and separation. (Table III).

TABLE III

LIGNIN (ARMITAGE) EXPRESSED ON DRY MATTER BASIS

Feed	11.33%
Rumen	19.73%
Reticulum	15.49%
Omasum	23.78%
Abomasum	18.52%
Small intestine	12.38%
Caecum	20.86%
1st Half Large Intestine	21.18%
2nd Half Large Intestine	21.04%
Faeces	22.16%

294. The most notable figure would seem to be the lignin content of the material in the small intestine. This shows a very marked fall, and from the limited data available it would appear to be due to the very considerable secretions taking place into this portion of the alimentary tract. Further work on this subject is now being continued.

PRELIMINARY GENETICAL AND BEHAVIOUR STUDIES ON THE MUGUGA ZEBU HERD

G. H. Lampkin

295. Most of this year has been devoted to the development of the experimental programme for the herd of 90 Zebu cows, which were obtained by the Division from the Northern Frontier Province of Kenya. These cows form the foundation herd from which animals will be bred for use in genetic studies at Muguga.

296. The stock were mostly young cows and, when examined in July, only 32 had full mouths. Several in fact had only four broad teeth, and for native stock were in very good condition. Fifty-one were in calf to unknown bulls when they were received.

297. During the year, valuable experience has been gained in the managing of this herd which, for several years, will be used to determine how important breeding actually is in programmes for improving livestock. Considerable attention has been given to devising means of controlling bulls and ensuring that only desired services occur, because the large number of bulls to be used in the experimental programme raises problems which are not encountered on normal farms.

298. From the 90 cows, 82 calves have now been born (37 males and 45 females) of which all but three are still alive. Unfortunately, eight cows have died (one Bloat, one Redwater, one from a displaced womb, and five from 'Ondiri-itis'), so that the herd now consists of only 82 breeding females. Their calves are being reared for beef, and are suckled on the dams until weaned when 36 weeks old. No supplementary feeds are fed to any cattle, as results are needed which show what can be achieved from grass alone. Table I gives some details of rates of growth, and shows that the main managerial problem at present facing us is how to keep calves thriving just after they are weaned. Attention will be focused on this point in the coming year.

TABLE I

SOME INFORMATION ABOUT N.F.D. CATTLE AT MUGUGA

Details	Calves Conceived Before 31/8/54		Calves Conceived Between 1/9/54 and 31/8/55	
Wt. of Dam one week after calving	*618 (23)		699 (56)	
	♂	♀	♂	♀
Wt. of calves at birth	43.7 (9)	45.5 (16)	55 7 (28)	46 9 (28)
Gain (lb. /week) between birth and 12 weeks	Not available		‡9 29 (23)	‡8 51 (17)
Gain (lb./week) 12-24 weeks	†7 87 (9)	†7.19 (15)	‡8 91 (15)	‡7.45 (7)
Gain (lb./week) 24-36 weeks	6.92 (9)	6.24 (15)	‡9.42 (5)	‡8.16 (1)
WEANED				
Gain (lb./week) 36-48 weeks	5 09 (9)	2.82 (15)		
Gain (lb./week) 48-60 weeks	‡2.67 (1)	‡3.17 (2)		

* : data missing for two calvings
† : birth-24 weeks, as 12-week weights were not available.
‡ : calculated on data available as some calves have not reached that age.
( ) : number of animals in average.

299. With the co-operation of Mr. E. M. Kidner, from the Grasslands Research Station at Kitale, and with Dr. J. Quarterman, studies on the grazing behaviour of Grade and Zebu steers have been commenced. These were started with a view to relating the results to the question of heat tolerance. A preliminary analysis indicates that differences in heat tolerance cause differences in behaviour, even in the relatively mild climate of Muguga, but that these differences are not large and, except for the quantity of water drunk, are probably not important.

EXPERIMENTS ON THE FEEDING OF BACON PIGS

M. H. French and H. P. Ledger

300. A pig unit is being maintained to produce a uniform type of pig, primarily for studies of food utilisation and conversion rates, and at the same time to produce the carcase quality required by the commercial bacon market. The herd has been developed from 4 pigs purchased from the Mpwapwa stud, and the aim now is to breed as uniform a pig as possible from these animals, which is so essential for work in food conversion studies. All progeny are individually fed and recorded.

301. A new Danish type pig house specially designed to enable the easy recording of the food consumed by individual pigs is being built by the Maintenance Superintendent, many of the specialised fittings being modelled on those developed at the Rowett Research Institute.

302. The sows are pastured outside, between litters, but are housed at night to minimise the risk of losses. Ten days before farrowing they are brought into pens, and during the suckling period are fed to maintain a good average condition. The piglets are creep fed from the age of three weeks until they are weaned. They are then placed in the feeding pens, and individual daily consumptions of food are recorded and liveweights are taken on alternate days. Green food of some kind is fed *ad lib.* to all housed pigs, and to illustrate the levels of nutrition employed at Muguga, the various ration mixtures now being fed to pigs of different weights and types are given below.

PIG RATIONS (lb.)

	BREEDING STOCK	BEFORE WEANING	BACONERS		
			From 30-90 lb. liveweight	From 90-120 lb. liveweight	From 120-210 lb. liveweight
Cassava Meal	9	17½	53	37	10
Barley Meal	9	—	—	20	45
Pollards	70	12½	30	30	35
Groundnut Cake	—	10	5	5	—
Lucerne Meal	—	2	3	3	3
Carcase Meal	5¼	—	14	4	4
Yeast	2	1	—	—	—
Lime	—	1	1½	1½	1½
Bone Meal	2	—	—	—	—
Salt	1	½	½	½	½

303. Feeding during the bacon period is adjusted according to appetite, and the animals are fed in twenty-minute periods three times a day in order that their consumption shall not be restricted by the experimental feeding procedure nor by the need to avoid wastage. Baconers are sent to the factory at 200 lb.-210 lb. liveweight, as experience has shown that our particular strain is mature at this weight. Through the co-operation of the Uplands Bacon Factory all pigs slaughtered are measured cold and the unit therefore is equipped for recording, as accurately as possible, individual food consumptions at varying ages and weights, the liveweight gains resulting from this food, the commercial assessment of carcase quality, and individual carcase measurements. Table II gives an example of the type of record being kept which refers to a single litter.

304. One of the points which need early clarification is the need for investigating how far weaning weights have any significant influence on subsequent food consumption to bacon weight, and whether the carcase from a pig of high weaning weight is different from that of the lighter weaners. Table III shows that weaning weights do not affect the efficiency of conversion of food to liveweight up to bacon weight, and it also shows the very satisfactory constancy of food conversion efficiency of this herd.

TABLE II

TYPE OF RECORDS BEING COLLECTED

Pig No.	Sex	Days from weaning to slaughter	Weaning weight lb.	Slaughter Weight lb.	Food Consumption lb.	lb. food per lb. L.W.I.	Dressed Carcase Weight lb.	Killing out %	Factory Grading	Fat Setting
201	F	98	46	206	479	3.0	151	73.3	A B B	VF
202	M	134	38	204	565	3.4	152	74.5	A A A	VF
203	M	134	32	204	545	3.2	154	75.5	A A A	VF
204	F	147	32	211½	591	3.3	160	75.6	A A A	VF
205	F	118	33	207	541	3.1	157	75.9	A C C	VF
206	M	147	29	202	571	3.3	150	74.3	A A A	VF
207	M	134	33	204	553	3.2	153	75.0	A A A	VF
208	M	134	36	208½	572	3.3	156	74.8	A A A	VF

CARCASE RECORDS

Pig No.	Length (in.)	Shoulder Fat (cm).	Loin Fat (cm).	Rump Fat A	Rump Fat B	Rump Fat C	Belly Thickness A	Belly Thickness B	Belly Thickness C
				cm.	cm.	cm.	cm.	cm.	cm.
201	30	6 2	3.2	4.5	4.1	4.5	3.7	2.5	4.1
202	30	5.2	2.3	2.7	2.7	2 8	2.7	1.7	3 3
203	31	5.1	2.0	3.4	2 6	3.0	3.0	2 8	3 6
204	31	4.5	2.5	3.3	3.5	4 0	2 8	2.3	2 2
205	30	6 8	3 6	4.9	4.7	4 5	4 5	2 5	4 3
206	30	4 6	2 8	3 5	2.7	3 1	3 2	2 3	3 1
207	31	5 1	2 1	2.7	2 5	2 6	3 0	2 4	3 4
208	30	5.3	2.9	3.5	2.7	3.3	2.0	2.6	3.5

TABLE III

FOOD CONSUMED FROM WEANING TO 200 LB. LIVEWEIGHT

Initial weight	MALES			FEMALES		
	No.	Average Food Consumption (lb.)	lb. food consumed per lb. liveweight gain	No.	Average Food Consumption (lb.)	lb. food consumed per lb. liveweight gain.
35 - 45 lb.	26	525.8	3.29	19	480.7	3.01
45 - 55 lb.	26	439.1	2.93	19	449.4	3.00
55 - 65 lb.	26	412.8	2.94	19	416.9	2.98
65 - 75 lb.	26	378.7	2.92	19	388.8	2.99

305. Two points of interest in the present series of tests concern (a) the efficiency of cassava meal instead of maize meal on food conversion rates and carcase quality and (b) the lowest level of expensive animal protein concentrates which permit both adequate growth and carcase quality. Although the trials are not yet completed, the results already prove the superiority of cassava over maize meal as a producer of firm carcase fats. On the protein levels, the results are in harmony with the conclusions of the Cambridge workers (Woodman and Evans) that past standards were pitched unnecessarily high.

EGG YIELDS FROM LOCALLY-BRED POULTRY

M. H. French and A. F. Dent

306. Details were given last year of the average annual egg productions of the five breeds of fowls comprising the Muguga unit during their first two years. This study has been extended to cover a third laying season and because a number of the original birds were not kept for the third season, the average yields in the first two years are somewhat different from those in the previous summary. The method of feeding was the same as already described and the results of the trap-nested birds are shown in the next Table.

AVERAGE EGG YIELDS OF IMPORTED BIRDS

Breed	First Year's Egg Yield	Second Year's Egg Yield	Third Year's Egg Yield
Brown Leghorn	157.0 (100%)	133.3 (84.7%)	103.1 (65.6%)
Cambar	212.3 (100%)	145.0 (68.3%)	107.0 (50.4%)
Legbar	176.0 (100%)	117.5 (66.8%)	102.0 (57.9%)
North Holland Blue	189.5 (100%)	134.7 (71.1%)	66.0 (46.4%)
Welsummer	165.9 (100%)	105.0 (63.2%)	81.9 (49.4%)

307. It was pointed out last year that the decrease in egg yield between the first and second year's productions was greater than would be expected from temperate area records. The further decrease between the second and third year's egg outputs was also larger than would be anticipated. In an attempt to determine whether this exaggerated decrease was a characteristic of stock hatched in temperate areas and flown out as day-old

chicks to Muguga, or was equally applicable to the F_1 generation reared from these imported birds, the following figures were secured.

AVERAGE EGG YIELDS OF F_1 BIRDS

Breed	First Year's Egg Yield	Second Year's Egg Yield	Second Year's Yield as % of First Year Output
Brown Leghorn	188.9	122.5	64.8%
Cambar	197.5	113.8	57.5%
Legbars	164.3	109.4	66.6%
North Holland Blue	178.8	117.2	65.6%
Welsummer	148.2	93.9	63.3%

308. From this summary it can be assumed that the decline in egg production between subsequent years is not related to the unlikely possibility of the transference of day-old chicks from temperate areas but is characteristic of such birds in the local environment. Quite obviously this tendency must have a significant influence on the management of commercial poultry units.

309. It is also instructive to record the first year annual egg yields of F_1 and F_2 generations bred and reared at Muguga with those of the original fowls flown out from Britian as day-olds.

AVERAGE FIRST YEAR EGG PRODUCTIONS OF IMPORTED BIRDS AND THE F_1 AND F_2 GENERATIONS BRED FROM THEM LOCALLY

Breed	Imported Birds	Locally Bred F_1 Birds	Locally Bred F_2 Birds
Brown Leghorn	141.5	180.8	202.4
Cambar	176.5	183.3	186.3
Legbar	145.5	157.1	156.2
North Holland Blue	141.1	160.7	156.5
Welsummer	138.8	129.0	120.4

310. During this past year the unit has been on a care and maintenance basis and no detailed experimental matings have been undertaken. Consequently, the improvement recorded last year in the egg yields of the F_1 generation over their imported dams has not been improved for the Cambar, Legbar and North Holland Blue breeds. A distinct improvement occurred with the Brown Leghorn but this must be ascribed to fortuitous rather than to designed matings. In the case of the Welsummer, the only breed in which egg yields of the F_1 generation were below those of their imported dams, the output of the F_2 birds was again disappointing.

EXPERIMENTAL FARM

A. F. Dent

311. In spite of difficulties experienced with labour due to the Emergency at the beginning of this period and the fact that Mr. H. P. Ledger, the Farm Manager, was away on overseas leave during part of this time, the past year has been marked by a considerable amount of progress. A start has been made on the clearing of an area of 60-70 acres recently transferred to the Farm from the Forestry Division of E.A.A.F.R.O. This land was exchanged for an area of approximately 80 acres on the far boundary of the farm, between it and the Native Reserve. An important advantage of this exchange will be that the new and future fields will be in close proximity to the farm buildings, so that cattle can be grazed with less risk of contact with African-owned stock in the Reserve and the consequent danger therefrom of introducing disease onto the farm. The importance of this point has been emphasised by a recent outbreak of Foot and Mouth disease in the adjoining Reserve, and the fact that no cases occurred among the A.I.D. stock.

312. After the experience of previous years, when substantial losses were incurred in arable cropping ventures due to factors entirely beyond our control, a new policy has been laid down during the current year; in future, only the land in view of the farm house will be used for arable purposes, and all other areas will be utilised for grass. During the year, three fields, out of sight of the farm buildings, have been planted to grass and only one field now remains to be planted. Due to the unexpected rains during December/January, approximately 15 acres of arable land were planted with Star grass. This field was completed during the long rains of 1956, so that at the present time there are 82 acres of Star grass and approximately another five acres of Kikuyu grass.

313. *Fodder Crops.* A small acreage of sugar beet was planted during the 1955 long rains, which yielded extremely well. The beet was analysed by Dr. J. Quarterman and showed a sugar content of 14.6%. A liberal dressing of F.Y.M. was applied to the crop, which responded well to this treatment. A random test yield gave 13.9 tons per acre of crowns and roots, and 5.7 tons per acre of tops. These yields compare favourably with those obtained in England, but it should be realised that the crowns and roots were unwashed. The results are most encouraging and it is anticipated that, after further research, the economic possibilities of this crop may prove attractive.

314. No kale was planted during 1955, but a small area was planted following a crop of potatoes during the 1956 long rains. Edible cannas have been tried on a small scale, and seem to be yielding well. They are a particularly useful stand-by during dry periods for providing succulent and green feedingstuffs for pigs and poultry. A small area of Sweet Potatoes was also grown; the tops were used as a green food for pigs, and the tubers were sold to the local inhabitants. The results proved very satisfactory. Oats grown for the production of hay yielded well and, in spite of the variable weather during the harvest of 1955, the farm was able to supply the Royal Agricultural Show at Mitchell Park, Nairobi, with all its requirements of Oat hay for the period of the Show.

315. *Cereals.* K8, an early-maturing maize from Uganda, was tried on a field scale but the yields were so unsatisfactory that its continuance during the 1956 planting season was not justified. No barley was grown during this last year as it was considered, on past experience, to be uneconomic.

316. *Legumes.* Fiwi beans have been planted on about two acres. These yielded extremely well, and their produce sells readily amongst the Kikuyu.

317. *Potatoes.* These were planted on a field scale and, due to the unexpected rainfall in December/January, a second crop of potatoes was harvested. The variety, Dutch Robijn, did fairly well and yielded over six tons per acre at each harvest. Four varieties of blight-resistant white potatoes, which were obtained in very limited amounts from Dr. R. M. Nattrass of the Kenya Department of Agriculture, have been cultivated and bulked for further large-scale trials.

318. *Long-Term Experiments.* The second year of the grassland experiments involving the cutting of over 7,700 plots and the conducting of two grazing trials on replicated Kikuyu pastures, was completed.

319. In conjunction with Dr. H. W. Dougall of the Kenya Department of Agriculture, work has continued for a third year to study the effects of fertilisers on the establishment and maintenance of a Star grass ley. With the completion of the grass phase, this ley was ploughed in this year and planted with swedes to evaluate residual phosphate responses in particular. A more complicated and extensive large-scale experiment on the effects of fertilisers on planted Star grass was commenced.

320. *Cattle.* During the year a herd of Kenya Northern Frontier cattle were purchased, and a fuller account of their development appears elsewhere in this Report. 'Ondiri' disease, about which very little is known, broke out among this herd, as a result of which several cattle died. It is hoped that the clearing of bush from the grazing lands near the forest reserve will hamper the range of activities of *Haematopota distincta*, a suspected vector of the disease.

321. *Sheep.* At the time of writing, the first crop of $\frac{3}{4}$-Dorset Horn \ Masai sheep are being born. A pure Dorest Horn ram was born at the beginning of March 1956, and the Dorset Horn ewe is due to lamb down in the near future. There has been no serious outbreak of disease in the flock during the past year but, unfortunately, financial stringencies have prevented expansion of this unit on the original scale.

322. *Pigs.* The pig unit has been increased to 14 breeding sows; this has been done by retaining the better gilts of certain litters from proven parents. More gilts are being kept back from the factory, and it is hoped eventually to establish a fixed breeding herd of 20 sows, together with an additional four sows to meet emergencies and for replacement purposes. Working with this number of sows, the output of baconers should be approximately 300 per annum. There are two adult boars in the unit and the two young boars, being kept from the herd as replacements, should be ready for service within the next four/five months.

323. All pigs were inoculated for Foot and Mouth disease during recent outbreaks but no cases occurred and the unit has been free of disease during the past year. The average number of piglets per litter has been 8.5, of which 8.0 have been sent to the bacon factory.

MISCELLANEOUS INVESTIGATIONS

Effect of "Onderi-itis" on the blood proteins of cows

324. J. Quarterman took advantage of an outbreak of "Onderi-itis" a disease suspected of being insect borne, to study the changes in blood

proteins of a cow which was infected with the disease and which developed a typical syndrome but eventually recovered. During the course of the disease there was a steady decline in the albumin-globulin ratio, and a drop in total blood protein caused by a decrease in the albumin content. The globulin fraction increased slightly, due largely to an increase in pseudo-globulin which, owing to the method of analysis, contained the γ-globulin fraction.

E.A. Milk Recording Scheme

325. G. H. Lampkin gave assistance to this Scheme, which has resulted in its decision to produce an annual report on the lines adopted by the Milk Marketing Board in England. This will make breed averages and other data more easily comparable.

Collection of Cattle Twins

326. Towards the end of the year an appeal was launched jointly with the Department of Agriculture and the Department of Veterinary Services of Kenya to locate and purchase monozygous twins. These will be used to improve the accuracy of certain future experiments. As a result of this appeal, five pairs have so far been obtained.

MISCELLANEOUS SCIENTIFIC SERVICES

JOINT E.A.A.F.R.O./E.A.V.R.O. LIBRARY

L. D. Verdcourt

327. Mrs. S. Evans was Acting Librarian during the first half of the period under review, whilst the Librarian was on overseas leave.

328. The setting up and amalgamation of the Veterinary section of the Joint Library posed some bibliographical queries. It was found that the classification scheme (Universal Decimal Classification) of the Veterinary Library would not fit in easily with the E.A.A.F.R.O. books, which are arranged according to a local system formulated at Amani, Tanganyika. It would be a formidable task to change either Library to another classification scheme, involving not only the physical position of the books on the shelves but also the typing of several thousand catalogue cards, and it was therefore decided to shelve the two Libraries separately (but within the same room) for the time being. This is not entirely satisfactory and is especially confusing to the newcomer, but no single classification seemed adequate to cope with the variety of scientific subjects made up by the two Libraries. With this problem in view the Librarian made many visits to scientific libraries in England and on the Continent, searching for an "ideal" classification scheme. This proved to be a most interesting tour but disappointing in that no satisfactory answer was found to our local problem. In the Ministry of Agriculture and Fisheries Library, for instance, the classification problem is dealt with as it is here by the use of two different schemes (U.D.C. and a simple local scheme), but in any case the majority of the fisheries books are housed at Lowestoft.

329. The good work done by the Bookbinding Staff was continued during the year. 1,153 books were bound and many cardboard boxes made to hold reprints and current journals. In addition many map tubes were made for the distribution of rainfall maps. The slight drop in output over the year was due to the fact that two learners were engaged, and also the Head Bookbinder went on long leave during this period.

330. Many requests for articles, reprints and microfilms were put in by the scientific staff. Personal contacts made by the Librarian whilst on home leave have proved most useful in obtaining quick photocopy services. The Librarian at Rothamsted Experimental Station has been particularly helpful with references and translations, as well as in the making of microfilm copies. A microfilm reader would be a very useful

piece of library equipment, obviating a good deal of work in processing the film when it is received from England.

331. On the whole the work of the Library continues steadily but it is felt that more time should be spent on revising the classification of the books, bringing the subject index up to date, and such jobs as routing periodicals round the research staff. This is quite impossible at present due to the fact that routine work takes up most of the Librarian's time.

332. Owing to the vast increase in the cost of printing both in America and England, the subscriptions to scientific periodicals have increased alarmingly in the past year or two. Some time was spent on reviewing the situation and it was found that the total cost of the standing order for periodicals for E.A.A.F.R.O. Library is now twice the 1954 price. This is very serious because due to the geographical position of the research station and the paucity of bibliographical material in the whole of East Africa, it is most necessary to have, as far as possible, a self sufficient Library.

333. It is regrettable that due to this financial strain, very few text books have been purchased during the year, but it is hoped that this situation will be amended during the coming year.

EAST AFRICAN AGRICULTURAL JOURNAL

D. W. Duthie

334. Fifty articles were published in the four numbers of Volume 21 (July 1955-April 1956), covering a wide range of subjects in agriculture, veterinary science, animal industry, forestry and fisheries. The number of books received for review is rising, and 21 reviews were published in this volume.

335. Several of the articles are comprehensive treatises on particular subjects; for example an article on the pests of Black Wattle is likely to be a standard reference for many years, while the series of three articles on muninga (*Pterocarpus angolensis*) is a detailed study of forest exploitation, regeneration, and replacement, which could be applied to other timber species as well. Two articles on the behaviour and control of the Sudan Dioch or Red-billed Finch are of considerable economic importance, as this grain-eating bird does great damage in some of the cereal-growing areas of East Africa. On the veterinary side, articles on fluorosis in cattle and on progressive pneumonia in sheep are of particular interest, while another article in the series by Professor Epstein of the

Hebrew University, Jerusalem, traces the origin of the Zebu cattle of East Africa. Six articles have appeared on animal management and feeding, one of these being a study of the importance of water in the management of cattle, a subject of vital interest to a large part of East Africa.

336. These articles, and others of equal importance in their particular branches of research, are of value in all tropical and sub-tropical territories, and are of particular value in East Africa, in that they provide records of work which might otherwise be available only in departmental files.

337. Although this Journal is primarily a technical periodical for publishing the results of experiment and research in East Africa, it is highly desirable that it should include more articles with a direct practical appeal. Unfortunately the practical agriculturist is reluctant to record his experience, and the majority of articles in practical farm journals are written by professional or free-lance agricultural journalists. Nevertheless it is hoped that a means may be found to fill this gap in this Journal.

EAST AFRICAN PLANT QUARANTINE STATION

F. M. L. Sheffield and P. J. Dickinson

Staff

338. On 1st November, 1955, Mr. P. J. Dickinson was appointed Horticulturist-in-Charge, the post having become vacant early in September. During the intervening period the Station was supervised by Officers of E.A.A.F.R.O.

Buildings

339. A further two glass-houses were received and erected bringing the total to ten houses, each of two chambers. This allows the simultaneous handling of 18 consignments whilst leaving two sections for the propagation of healthy test plants.

Importations and Releases

340. *Food Crops.* The Director of E.A.A.F.R.O. continued to import Sugar cane varieties on behalf of the three East African Territories, and also imported an American bred variety of Sweet potato at the request of the Uganda Department of Agriculture. He wishes to express

his gratitude to the Directors of all the Organisations who so willingly sent cuttings upon request.

341. *Sugar Cane.* The following 20 varieties[1] were received at the Quarantine Station during the period 1st July, 1955-30th June, 1956, and are now being held there in closed quarantine :

Supplied by the Department of Agriculture, Nyasaland:

CP.29/291	CP.34/39
CP.29/305	Co.464

Supplied by The Imperial College of Tropical Agriculture Trinidad, British West Indies:

Pindar	Q.47
Comus	Q.50
Eros	Q.56
Ajax	Q.57

Supplied by the Sugar Cane Breeding Institute Coimbatore, India:

Co.678
Co.775

Supplied by Experiment Station, South African Sugar, Mt. Edgecombe, Natal, South Africa:

Co.356	CP.36/111
Co.527	N.Co.376
Co.622	N.Co.382

342. Below are listed 23 varieties which were released from close quarantine at Muguga. Three sets from each were heat-treated against Ratoon-stunting disease, and are now established on the terraces at the Station forming the nucleus of a new collection to be held there. All the remaining setts were sent to the Kawanda Agricultural Research Station, Uganda, where they received heat-therapy before being planted out to multiply whilst in open quarantine for a further year. These varieties are :

[1]The initial letter prefixing the varietal number refers to the country of origin:—B. Barbados; Co. Coimbatore, India; CP, Canal Point, Florida; H. Honolulu, Hawaii; M. Mauritius; N.Co, raised in Natal from Coimbatore seed; POJ, Proefstation Oest Java; PR, Puerto Rico; Q. Queensland.

B.37172	N.Co.292	Pepe Cuca
B.4098	N.Co.293	H.32/8560
Co.396	M.112/34	H.38/2915
Co.475	M.165/38	H.38/4443
Co.513	M.423/41	H.39/3633
Co.602	PR.905	H.39/5803
Co.617	PR.1000	H.39/7028
	POJ.3016	H.44/3098

343. *Sweet Potato.* Cuttings of the variety "Early Port" (L.2/40) were obtained from the Division of Horticulture, Department of Agriculture, Pretoria, S. Africa. After being grown and tested in quarantine, cuttings were sent to Makerere College, Kampala, and a few tubers were sent to the Department of Agriculture, Seychelles.

344. *Coffee.* Ten seedlings of *Coffea arabica* var. *cumbaya* (P.I. No. 220715) from U.S.A. were quarantined at the request of the Kenya Department of Agriculture. After three months observations, the whole consignment was released to the Jacaranda Coffee Research Station, Ruiru.

345. *Ornamentals.* The ornamentals we expect to receive into quarantine most frequently are Arum Lilies, *Begonia*, *Dahlia* and *Chrysanthemum*. These are known often to be symptomless carriers of Spotted Wilt virus and also of other viruses whose potential danger to East Africa is not fully understood. We therefore destroy all plants found to be carrying a virus.

346. Each consignment is kept in a separate glasshouse chamber and the number of chambers available is restricted. Therefore in order to make the best use of available space, not more than five plants of any one variety may be imported and each consignment must fill a chamber (i.e. consist of 25 plants). The Kenya Department of Agriculture agreed with the Kenya Horticultural Society that Importation Permits should be issued only to certain growers selected by the latter. The individual desiring only a few varieties would need to import through one of the named growers.

347. In the previous year trial importations of the above species were made by the Quarantine Station in order to experiment in methods of handling and testing. All the plants were later destroyed. These and

the commercial importations we are now receiving have shown the stringent regulations controlling the importation of ornamentals to be fully justified. We have not yet identified Spotted Wilt virus in any of the importations[1] but, in only one case, have we been able to release a consignment complete. Some others have contained over four-fifths of virus-infected plants.

348. No commercial importations of Arum Lilies or *Begonia* have yet been received but a consignment of the latter is expected early in July. The first commercial importation of *Chrysanthemum* received, consisting of five plants of each of five varieties, was released complete. A double consignment of 50 plants comprising 15 different varieties was received in March. All but eight plants of five varieties have been found to be virus infected and have been destroyed. The remainder are being retained for further testing. Of the first commercial importation of 25 *Dahlia* plants comprising five varieties we were able to release only 15 plants of four varieties. Nine plants of a second similar consignment have already been destroyed and the remainder are being held for further testing. A third consignment is expected early in July.

Experimental Work

349. *Conifers.* There is a possibility that Pinus grafting material will be imported through quarantine. Experiments have therefore been made in the technique and management of grafts of *Pinus patula* and *P. radiata* under glasshouse conditions. 60% of the grafts were successful; it is clear that this material could be satisfactorily handled in closed quarantine.

350. *Sugar Cane.* Difficulty has often been reported in rooting and germinating setts which have been heat-treated for the control of Ratoon-stunting disease. Experiments have been started in the management of such cuttings. Hormone did not seem to help germination and rooting, but, with the variety used, heat treatment had no deleterious effect. Varieties vary in their susceptibility to the heat treatment, and it is hoped to experiment further using a variety known to be highly susceptible.

[1]Spotted Wilt virus was identified in some imported dahlias received in July, 1956.

ATTACHED C.D. AND W. SCHEMES

ECOLOGICAL TRAINING SCHEME

C. G. Trapnell

351. Financial provision for the Ecological Training Scheme was extended to the end of the period under review. At the outset two officers were still in training, Mr. D. I. Nicholson, Ecologist for the Forest Department, North Borneo, and Mr. J. G. Wilson of the Uganda Agricultural Department who was completing a six months' course for vegetation and soil survey in Karamoja. Mr. Wilson returned to his base at Moroto in July, after carrying out a short independent reconnaissance of *Acacia-Commiphora* types of vegetation on a selected route through southern Kenya and north Tanganyika. Mr. Nicholson was at that time in Mpanga Forest in south Mengo district, Uganda, where. he had been engaged on a detailed study in forest ecology under Mr. H. C. Dawkins of the Forest Department, Entebbe.

352. As Mr, Nicholson was training for ecological work under humid Rain Forest conditions, arrangements were made for a visit to the I.N.E.A.C. Research Centre at Yangambi. In mid-July I joined him at Entebbe and proceeded by car with him on the route Beni-Irumu-Stanleyville, which allowed an examination of remnant high forest areas on the way. The amount of dominance, varying with soil conditions of *Cynometra* and *Macrolobium*, was an interesting aspect of this journey. Nine days were spent at Yangambi with the Divisions of Forestry, Botany, Agrology and Climatology, and the help and hospitality which were accorded to us are gratefully recorded. Demonstrations of forest enrichment plantings, the *couloir* system of agriculture, pasture establishment and the Yangambi soil catena were kindly provided, and the distinctive vegetation of the Pleistocene sand soils was also examined.

353. The return journey was made via Irumu-Pakwach to Gulu, north Uganda. From here Mr. Nicholson left for a few days visit to Budongo Forest, which offered a valuable comparison with the Congo *Cynometra* areas, after which he returned via Entebbe to Kenya. In the meantime I was met at Gulu by Mr. Wilson with a view to making an initial series of traverse recordings of vegetation types in Karamoja. These were carried out between Kaabong in the north and the southern border of the district, and a provisional outline vegetation classification was drawn up. An overall vegetation map of Karamoja has since been

completed by Mr. Wilson. Four zones in this region are of particular consequence for land use purposes, the *Combretum* wooded grasslands of the moister northwest and the Kadam area, the chain of *Acacia* black clay grasslands down the middle west, a central zone of highly altered *Acacia-Lannea* scrub-grassland (which includes clay soils masked by superficial sand and gravel) and the more arid belts of the eastern *Acacia-Commiphora* bushlands which are characterised by *Acacia mellifera*. Several of the grassland reclamation trials, previously established by Wilson through these zones, were also visited.

354. After our return from Uganda in August Mr. Nicholson drew up the results of his Mpanga forest work, which were transmitted to Mr. Dawkins at Entebbe. At the beginning of September a small further reconnaissance was carried out in the Nyanza Province of Kenya, taking in the country between the Nandi escarpment and the Nzoia river. This area contains abrupt transitions from present and former evergreen forest areas to *Combretum* country. Useful results were obtained on the indicators of the old forest zone in the cultivated areas (characterised particularly by *Croton macrostachys*) and traverse records were kept of the topographic and soil variations found within it. The air cover was examined on return, and the main zonal boundaries were plotted on the 1/50,000 maps of the area. These data will be used in subsequent work in Nyanza Province.

355. At the beginning of October Mr. Nicholson left for North Borneo, after which I was on overseas leave until the end of April. After returning, work was begun on the arrears of data accumulated in the course of the field work of the Training Scheme. A joint account with C. F. Hemming of a reconnaissance soil classification of the South Turkana region was first completed. In the field of vegetation-soil relations observational data are being compiled on structural differences in soils of the red earth order, which became apparent during work in Nyasaland. At the same time a long overdue record of ecological results of the burning experiments of the Forestry Department, Northern Rhodesia, is being prepared with a view to later publication. These experiments, now well known in forestry circles, have an important bearing on the ecology of *Brachystegia-Isoberlinia* woodlands in East Africa. A communication on the endemic flora of the northern Kalahari Sands was also submitted for a meeting of experts in Phytogeography at Yangambi.

EAST AFRICAN CEREAL PEST SURVEY

356. Dr. I. W. B. Nye of the Colonial Pool of Entomologists based at the Commonwealth Institute of Entomology is spending two years in East Africa carrying out this survey in co-operation with departmental entomologists. He arrived in the middle of March and has been collecting and working on material from Kenya, Tanganyika and Uganda. The principal cereals being studied are maize, sorghum and millet which have as their main pests, fly larvae in the young shoots, stem boring caterpillars and seed feeders.

357. The work will involve a study of the distribution of the various species and the classification not only of the adults, but also of their larvae which actually cause the crop loss and are the stage most commonly found in the field.

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